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RIPARIAN HABITAT ANALYSIS
Tonto National Forest

by
Alton E. Higgins & Robert D. Ohmart

RIPARIAN HABITAT ANALYSIS

TONTO NATIONAL FOREST

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RIPARIAN HABITAT ANALYSIS

Tonto National Forest

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USDA Forest Service
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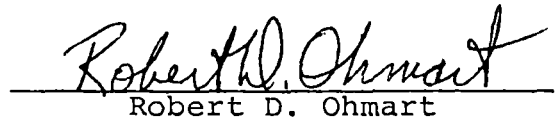

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ABSTRACT

A one-year riparian habitat analysis was conducted on the Tonto National Forest. The purpose of the two-part study was (1) to determine the extent, nature, and quality of riparian habitat existing on some 600+ miles of targeted waterways and (2) to provide information related to the composition and density of land vertebrates (birds, mammals, reptiles, amphibians) and the major riparian communities of the Salt and Verde rivers.

In Part I, aerial photographs were used to delineate potential riparian habitat, which was then classified (composition and structure), mapped, and assessed as to health and viability from the ground. Riparian communities on each stream were rated on a scale from one (Poor) to five (Excellent) based on the average score of seven quantified habitat attributes. Streams were divided into reaches based on the life zones through which they flowed (Lower Sonoran, Upper Sonoran, Transition). These reaches were evaluated and rated using the community ratings. Threatened and endangered species were also noted. Results indicated that 50 percent of the reaches were in a Poor condition in 1980, only 3 percent were considered Excellent. In 93 percent of the comparisons, the lower reaches were in as poor or poorer condition than the upstream sections, thus concentrating the more deteriorated sections in the lower altitudes. Eighty percent of the streams flowing through the Lower Sonoran Zone were in Poor condition, 46 percent of the reaches flowing through the Upper Sonoran Zone were Poor, and only 5 percent of the Transition Zone reaches were Poor.

Observations of three threatened or endangered plant species and five bird species were summarized. Recommendations included the establishment or initiation of (1) internal review of the USDA Forest Service policy, (2) primary use areas for special interest species, (3) pasture resting via rest-rotation, (4) improved range practices, (5) habitat improvement, and (6) a National Park in the Sierra Ancha range.

In Part II the ecological characteristics of five vegetation structure types are presented, based on data collected from 17-21 transects averaging approximately 2500 feet in length. The riparian communities were described by means of percent ground cover, relative foliage volume, foliage height diversity, horizontal foliage diversity, tree and shrub counts, timing of phenological events, and velvet mesquite pod production. Can traps and drift fences were used to sample reptile and amphibian populations. The cottonwood-willow community had the highest densities of both reptiles and amphibians, and eight of the nine species captured during the study occurred in this vegetation type. Small mammals were sampled by means of snap-trap grids. Nine species were captured, seven each during the summer and winter seasons. Species occurrence and densities may have been affected by the unusually lush herbaceous growth characterizing many of the study areas after the very wet winter of 1979-80. Bird densities were calculated for five seasons (winter, spring, summer, late summer, and fall). The cottonwood-willow community had the greatest number of species each season, averaging nearly 13 species more than the next richest community. The velvet

mesquite structural type characterized by tall, dense trees had more species than the other types of velvet mesquite. The velvet mesquite bosque near Needle Rock on the Verde River supported obligate riparian bird species near the level observed in the cottonwood-willow community. It was recommended that (1) riparian areas on the Tonto National Forest not currently developed should be given protective status, (2) rest-rotation grazing procedures be implemented, and (3) release rates from Bartlett Dam on the Verde River should be maintained at 200 cfs.

PART ONE

RIPARIAN VEGETATION ON THE TONTO NATIONAL FOREST

INTRODUCTION

Ecologists have long been aware of the unique vertebrate assemblages occurring in the southwestern United States, particularly those found in the riparian habitat of Arizona. It was not, however, until the early 1970's that the magnitude of the value of riparian habitat was realized, in addition to the scarcity of this resource (Carothers et al. 1974, Hubbard 1977, Johnson et al. 1977). Ever decreasing amounts of this invaluable resource remain each year; the current status can only be characterized as critical. The intractable forces that have directed and are maintaining the continued degradation of the riparian habitat are complex and controversial, which is to say, much remains to be learned and difficult decisions are being made and will continue.

The USDA Forest Service, charged with managing a large percentage of the public lands in Arizona, has started a program to inventory and analyze the riparian habitat occurring on the Tonto National Forest. Over 600 miles of perennial streams were designated for study and inventory in the one-year phase of the total riparian habitat initiative reported here.

DESCRIPTION OF STUDY AREA

The Tonto National Forest, located in central Arizona, encompasses 2.9 million acres of land, including parts of four counties, Gila, Maricopa, Pinal, and Yavapai. Riparian habitat is located at all elevations, ranging from <1500 feet in the

Lower Sonoran Zone to near 7500 feet at the crest of the Mogollon Rim.

The Tonto National Forest is characterized by extremes of climate and terrain. Summer temperatures often exceed 100°F, particularly in the Lower Sonoran Zone. Roads above 5000 feet may be closed during winter because of snow; accessibility to many areas is limited or hampered by rough terrain and impassable roads.

Three major life zones are bisected by the watercourses of the Tonto National Forest. The Lower Sonoran Zone occurs from the lowest elevations to approximately 3000 feet. The most prominent vegetational features of this zone include the saguaro cactus (Carnegiea gigantea) and the palo verde tree (Cercidium spp.).

The Upper Sonoran is the most diverse of the three zones, varying from open grassland to impenetrable chaparral, and including the open woodland formation dominated by pinyon pine (Pinus edulis) and juniper (Juniperus spp.). The altitudinal limits of the Upper Sonoran Zone vary, as in all the life zones, as a function of exposure and/or local climatic and edaphic conditions, but generally extend from around 3000 to 5000 feet.

The Transition Zone, dominated by ponderosa pine (Pinus ponderosa), exists at elevations above 5000 to 7500 feet including the Mogollon Rim at the northern extreme of the Tonto National Forest. Elements of the next higher zone, the Canadian, such as white pine (Pinus strobiformis), Douglas fir (Pseudotsuga menziesii), and occasionally limber pine (Pinus flexilis), are

interspersed with the more typical Transition Zone flora along the streams and on north-facing slopes.

METHODS

Mapping

Riparian vegetation of perennial streams was delineated onto field work sheets from USDA Forest Service aerial photographs. Identification of riparian community and structural types from the aerial photographs was not possible, nor was it possible to identify small or scattered streamside plants from the aerial photographs. In addition, the existence or nonexistence of riparian vegetation in canyon bottoms was often impossible to confirm due to the restrictions of visibility imposed by physical features or shadows.

The delineated vegetation was classified as to community and structural type from the ground. Additional vegetation not visible on the aerial photographs was included on the work sheets when encountered. Corrections were also made where areas of delineated vegetation no longer existed, and when such delineations were of nonriparian vegetation. The riparian vegetation of each creek was thus ground truthed as far as was physically practicable. The resulting community classifications were then transferred to mylar sheets corresponding to the appropriate U.S. Geological Survey maps.

Community Types

Major riparian community types included velvet mesquite (*Prosopis velutina*; VM) and various mixed broadleaf associations. Areas of riparian vegetation dominated by one or two broadleaf

species were named after the species present. Areas supporting three or more broadleaf species in more or less equal numbers were identified as Mixed Broadleaf (MB) communities. The three major species in each Mixed Broadleaf community were identified on the work sheets and mylar overlays, in addition to the Mixed Broadleaf designation of the communities.

Structural Types

The scope of the mapping portion of this project did not permit quantification of vertical diversity of vegetation for each community type on each stream. This would have been the preferred procedure for designating and labeling the various riparian communities as to structural type, an aspect of community composition that has been demonstrated to be of great significance in terms of wildlife use values in riparian communities of the lower Colorado River valley (Anderson and Ohmart 1977). Identification of structural type was done qualitatively by the field biologists, each of whom was experienced with the structural type classification system employed by the riparian research project referred to above. Many hours of observation and discussion were spent in the field prior to and during the mapping of the assigned streams to ensure that designations were at least consistent. However, as in most natural systems, structural types exist as continua with intergradation between the types, and many situations were encountered which could not be easily categorized.

For our purposes, structural type was visualized as a function of the percentage of vegetation existing in several

layers. These layers, based on a system first proposed by MacArthur and MacArthur (1961), included the grass layer (any vegetation existing from ground level to 2 feet), the shrub layer (vegetation above 2 feet to 15 feet), and the tree layer (vegetation existing $\geq$20 feet). The proportion of vegetation in each of these layers was estimated visually, forming the basis for classification of an area into one of six defined structural types.

Structural Type I characteristically contained tall trees, most >20 feet high. Vegetation in the highest layer generally formed a closed canopy overhead, but significant percentages of vegetation were also present in the two lower layers (Figs. 1 and 2).

Structural Type II was somewhat similar to Type I. Canopy cover was sometimes more sparse than in Type I, with breaks occurring in the foliage above the shrub layer in some Type II areas. The shrub layer was often well defined in Type II, but this varied as well. When the shrub layer was not well represented, however, the tree layer was more strongly pronounced. The one consistent characteristic of Type II was the paucity of foliage in the lowest layer; it was often completely absent (Figs. 3 and 4).

Structural Type III possessed significant percentages of foliage in all three layers. The factor separating it from Type I was the height of the trees; in Type III little vegetation existed above 30 feet (Figs. 5 and 6).

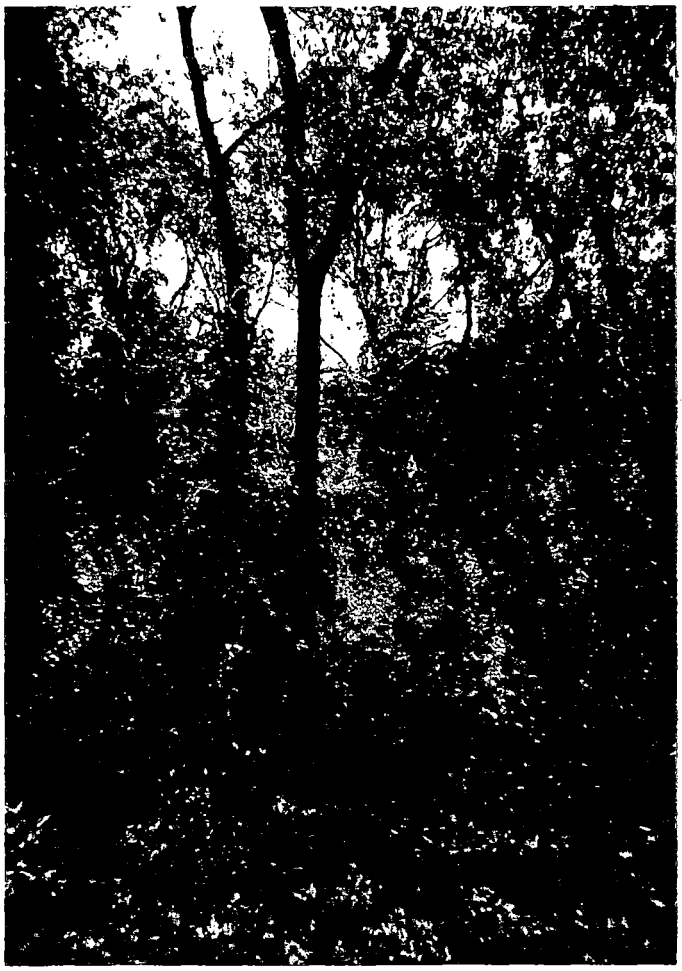

Figure 1. Structural Type I,
Turkey Creek.

Figure 2. Structural Type I, Sycamore Creek (Sheep Bridge).

Figure 3. Structural Type II, Houston Creek (tributary to Verde River).

Figure 4. Structural Type II, Pinal Creek.

Figure 5. Structural Type III, Ash Creek.

Figure 6. Structural Type III, Rock Creek (tributary to Rye Creek). Note pseudoriparian understory.

Structural Types IV through VI were dominated by vegetation below the tree layer. Widely spaced mature trees were sometimes observed in areas classified as Type IV, occasionally making the separation of Types II and IV problematic. The vast majority of the foliage in Type IV was ≤20 feet (Figs. 7 and 8).

Areas identified as Structural Type V contained few, if any, mature trees. Vegetation was mostly <15 feet high; foliage varied from sparse to dense (Fig. 9).

In Type VI the greatest percentage of vegetation was below the 10-foot level. There was generally very little foliage volume in this type, and trees were generally young or very small and widely spaced. It was sometimes difficult to determine when to classify an area as Type VI, or when to consider that no riparian community worth classifying existed.

The final structural category used was developed during the latter part of the mapping effort. The "scattered" designation refers to areas where widely spaced individuals, generally mature, exist without an obligate riparian understory.

Riparian Habitat Assessment (RHA)

Evaluation of the relative health of riparian systems cannot be accomplished via community and structural type designations. For example, Figure 5 depicts a rather healthy Sycamore (SYC) Type III community. Vegetation in the lower levels is composed of obligate riparian forbs, grasses, and shrubs. Figure 6 illustrates another Sycamore Type III situation, but one that is slowly dying. This area has acquired a pseudoriparian understory characterized by species in the genera Juniperus, Berberis,

Figure 7. Structural Type IV, Cherry Creek.

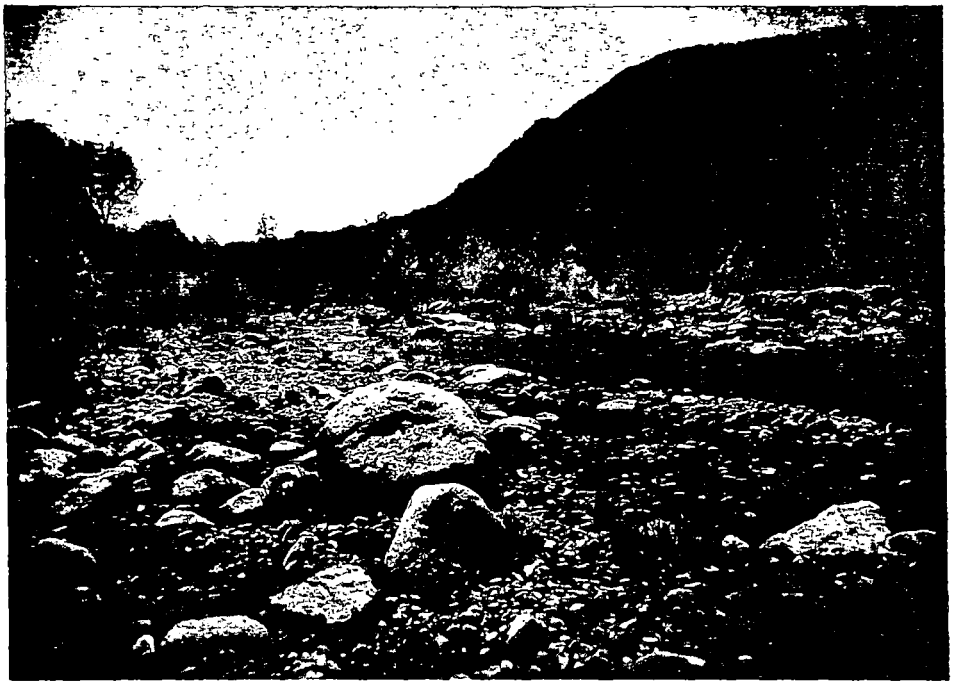

Figure 8. Structural Type IV, East Verde River.

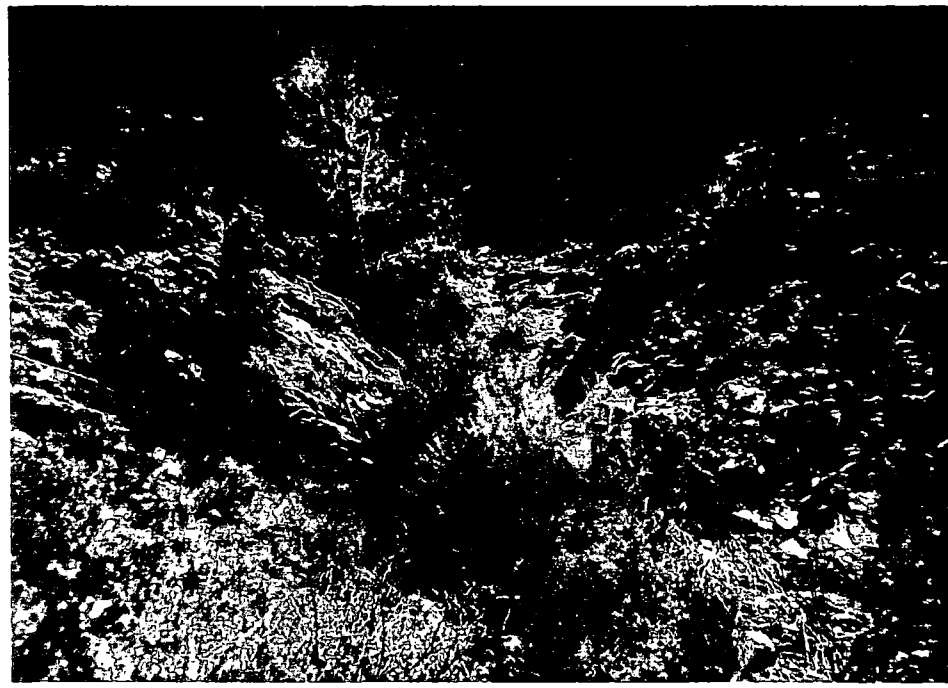

Figure 9. Structural Type V, Rogers Canyon.

Mimosa, Acacia, and other xerophytic genera normally occurring on hillsides. We developed a technique for quantifying the number of new individuals in a community and the overall condition of the community which was employed at least once, when possible, on each stream visited. Thirty 50-foot squares were used to sample a 3000-foot stretch of what appeared to be a representative section of stream in terms of the criteria to be quantified. We did not sample separately each community-structural type identified on each stream, however, all major riparian community types encountered on the Tonto National Forest were sampled. Obligate riparian tree species were counted and listed in a trunk diameter or diameter at breast height (dbh) category. The divisions used were 0-1", 1-2", 2-4", 4-8", 8-12", and >12". Presence of obligate riparian shrubs was noted for each 50-foot square. In addition, as a potential measure of degradation, the numbers of trees and shrubs considered to be pseudoriparian invader species were counted. This category included such species as juniper (Juniperus spp.), acacia (Acacia spp.), mimosa (Mimosa spp.), and scrub oak (Quercus turbinella). High and low elevation was also recorded.

Rating of Community Types

The RHA evaluations were used to rate the recruitment and condition criteria of the various community types, based on a scale from one to five (1 = Poor, 2 = Fair, 3 = Moderate, 4 = Good, and 5 = Excellent). Seven attributes were examined from the data collected in the Riparian Habitat Assessments. These were: (1) average number of species of riparian trees per

quadrat; (2) diversity of age classes, using information theory (Shannon and Weaver 1949); (3) average frequency of shrub species per quadrat; (4) average density of invader species per quadrat; (5) average number per quadrat of trees with a dbh $\geq$8 inches; (6) the number of species of riparian trees reproducing (Reproductive Diversity); 7) average number of new individuals (trunk diameter $\leq$2 inches) per quadrat (Recruitment). Factors 1, 2, and 3 address riparian habitat composition and structure, factors 4 and 5 are measures of habitat degradation, and factors 6 and 7 are measures of habitat viability.

Values for each of these factors were computed for each assessment. Each value for each assessment was then given a value ranging from 1 to 5, where 1 = Poor and 5 = Excellent. Assignment of these rating values was accomplished by subjective division of the values characteristic of each of the seven factors or attributes examined (detailed in Table 1).

Overall Rating

The values obtained by averaging the ratings awarded each of the seven habitat attributes were used in part to rate the Riparian Habitat Assessments, with some qualifications. The scale used to rate the assessments was somewhat lower and higher at the extremes than might be expected, due to the unlikely event of scoring at the same level for each factor, and the inequality of the value and utility of some of the attributes.

An overall rating of Poor was assigned to RHA's scoring in the range of 1.0 to 2.1. Some general criteria for assessments rated as Poor were that at least two of the seven factors must

Table 1. Division of riparian habitat attributes for rating purposes.

Factor - Description	Ratings				
	Poor	Fair	Moderate	Good	Excellent
1 Species/quadrat*	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	4.1-5.0
2 Age class diversity	≤1.39	≤1.54	≤1.66	≤1.73	≤1.79
3 Shrub frequency	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.0	≥4.1
4 Invader species	≥4.1	4.0-2.1	2.0-1.1	1.0-0.6	0.5-0.0
5 No. trees ≥8" DBH	0.0-1.0	1.1-2.0	2.1-3.0	3.1-4.5	≥4.6
6 Reproductive diversity	0.0-2.0	3.0-4.0	5.0-6.0	7.0-8.0	≥9.0
7 Recruitment	0.0-1.0	1.1-3.0	3.1-6.0	6.1-10.0	≥10.0

* Values for each factor (except 2 and 6) represent the average found in each 50-foot-square quadrat.

have scored a 1 (Poor), with an additional 1 for each 4 (Good) or 5 (Excellent) factor rating. A maximum of one 4 and 5 rating each was allowed, except that no 4's or 5's were allowed in the Recruitment category.

Assessments categorized as Fair had an average factor rating ranging from 1.9 to 2.6. Two or fewer 4's and 5's were permitted, and no 5's were permitted in the Recruitment category. Assessments rated as Fair contained three or less 1's.

A Moderate rating was assigned to those assessments scoring in the range of 2.7 to 3.0. These assessments contained three or fewer 4's and 5's, and no 1's were allowed for the Recruitment factor.

The assessments rated as Good (range 3.1 to 3.5) contained not more than two 1's or 2's. No values less than that awarded the Moderate rating (3) were allowed in the Recruitment category.

An Excellent overall rating was awarded to those assessments with an average rating for the seven habitat attributes considered that was $\geq$3.6, provided that at least one 5 and three 4's, or two 5's and no 1's or 2's were included in the attribute scores. Not more than one 1 or 2 was permitted, and no 1's or 2's were allowed in the Recruitment category.

Streams were divided into reaches based on the life zones and altitudes through which they flowed. Communities within these areas were used to evaluate the reaches. This was accomplished on a percentage basis, using the percentage of each community type as measured linearly within each reach. This

value was multiplied by the appropriate community rating value; the sum of all the values resulted in the rating for the entire reach.

Endangered Species

It was not possible to search all areas systematically for all state and federal threatened and endangered species of plants and animals. However, concerted efforts toward learning species characteristics were made, and these species were noted when encountered.

RESULTS

Mapping

Of the approximately 609 miles of streams and perennial waters that were to have been mapped and classified, a number of creeks, representing approximately 8.5 percent of the total mileage, were not visited. These included Deadman, Sheep, Alder, Lime, Squaw, and Del Shay creeks. These drainages were checked and mapped via low-flying fixed-winged aircraft. Approximately 85.5 percent of the mileages remaining on the visited creeks were successfully ground truthed. Extremely rough terrain was the primary factor preventing access to remaining areas (Table 2). On the visited streams, 69 percent of the combined reaches (450 miles) supported some sort of riparian vegetation (Table 3).

Communities

Deciduous broadleaf trees, particularly sycamore (Platanus wrightii), cottonwood (Populus fremontii), and alder (Alnus oblongifolia; ALD) dominated riparian areas. Riparian communities observed included a small amount of salt cedar

Table 2. Creek portions not surveyed.

Creek	From	To	Number of miles	USGS quadrangle maps
Boyer Canyon	Where it enters S36, T6N,R12E	Confluence with Salome Creek	2	Armer Mountain
East Verde	3.5 miles below L F Ranch	Confluence with Verde River	11	Cypress Butte, Cave Springs
Reynold's	Below Globe-Young Highway	Confluence with Workman Creek	2	McFadden Peak
Salome	Confluence with Park Creek	4 miles below Boyer Canyon	12	Copper Mountain, Armer Mountain
Spring	Flying W Ranch	Confluence with Tonto Creek	7	Buzzard Roost Mesa, Diamond Butte, McDonald Mountain
Tonto	0.5 miles below Bear Flat Campground	Confluence with Houston Creek	17	Promontory Butte, Diamond Butte, McDonald Mountain
Workman	Below Globe-Young Highway	Confluence with Salome Creek	5	McFadden Peak, Armer Mountain, Copper Mountain

Table 3. Analysis of riparian habitat on the Tonto National Forest.

Category	Mileage	Percent of total	Life zone percentages		
			Lower Sonoran	Upper Sonoran	Transition
Total examined	652	100.0	40.6	43.7	15.7
Type I	25	3.8	11.4	34.2	54.4
Type II	130	20.0	34.0	56.0	10.0
Type III	70	10.7	22.0	55.0	23.0
Type IV	115	17.6	42.5	43.0	14.5
Type V, VI	40	6.1	30.0	40.0	30.0
Scattered	70	10.7	40.0	38.0	22.0
No riparian	202	31.0	54.0	39.6	6.4
All riparian	450	69.0	34.6	45.6	19.8

(Tamarix chinensis; SC)-dominated vegetation, velvet mesquite associations, and cottonwood-willow (Salix gooddingii; CW) in the Lower Sonoran Zone, and various Mixed Broadleaf associations at higher elevations. These communities existed almost exclusively as narrow bands in and adjacent to the streams; stands of riparian vegetation wider than 200 feet were rarely encountered. Wide floodplains potentially capable of supporting broad stands of riparian vegetation were concentrated primarily at or below an elevation of approximately 3500 feet. These areas were characterized, with few exceptions, by evidences of both recent and long-standing degradation.

The distinction between riparian and nonriparian communities, particularly in the Transition Zone, was at times difficult, possibly due to the increasingly mesic nature of the terrain at higher altitudes. Stands of maple (Acer spp.; MAP) and walnut (Juglans major; WAL), for example, often occurred not only in riparian associations, but on adjacent slopes independent of riverine situations. Such stands, or similar associations, were not generally included or described as riparian communities when they occurred independently and separately from the streambed or floodplain.

Structural Types

The structural types dominated by tall trees, Types I through III, were all observed on the streams of the Tonto National Forest, but at far from equal occurrences (Table 3). Type I, the high-canopied gallery forest structural type, was least common, occurring on only 3.8 percent of the mileage of all

the targeted waterways of the Tonto National Forest. This rare structural type was best represented on Devil's Chasm Creek and Sycamore (at Sheep Bridge) Creek, although small patches were identified on a number of other creeks (such as Salome, Cherry, Webber, Tonto, Canyon, Pueblo, Tangle, and Turkey). Type II was the most common, being observed on 63 percent of the streams and characterizing 20 percent of the mileage of the streams on the Tonto National Forest.

Of the shrubby structural types, IV through VI, Type IV was the most widespread, occurring on 67 percent of the streams. The greatest concentration of Type V was on the East Verde River. Table 4 presents a listing of sites representative of the structural types existing within each of the six administrative regions of the Tonto National Forest. These localities were selected because of their easy accessibility to permit ready reference points for future comparisons with other areas, as well as to provide starting points for monitoring and/or further study as conditions change.

Riparian Habitat Assessment

Riparian Habitat Assessments were done on all creeks visited except Tonto, Salome, Sycamore (Sheep Bridge), Cold Spring, and Pueblo Canyon. The assessment from Devil's Chasm Creek was considered to adequately reflect conditions on the latter two streams and was applied to them as well.

Fifty-four Riparian Habitat Assessments were conducted in a variety of riparian habitat types occurring on 42 of the targeted creeks and rivers of the Tonto National Forest. The ratings of

Table 4. Tonto National Forest regional breakdown of accessible structural type localities.

Region	Structural type localities
Cave Creek	MBI - Sycamore at Sheep Bridge
	MBII - Seven Springs Wash, Cave Creek, Tangle Creek
	MBIII - Cave Creek (within Type I)
	SYCIV - Bronco Creek
	VMIV - Cave Creek where it meets Spur Cross Road
	Scattered - Cave Creek where it meets Spur Cross Road
Globe	SYC(MB)II - Pinto Creek by Howell Ranch 287/287A crossing
	ALDIII - Pinto Creek by Howell Ranch 287/287A crossing
	MBIII - Queen Creek just upstream of Arboretum
	VMIV - Queen Creek in Superior
	SYC/WALIV - West Fork of Pinto Creek
Mesa	SYCII - Sycamore Creek and West Fork, Sunflower Campground
	MBV - Rogers Canyon
	MBII - Rogers Canyon; Sunflower Work Center on Sycamore Creek

Table 4. (cont.)

Region	Structural type localities
Mesa (cont.)	CWII - Blue Point Cottonwood area; Fish Creek Canyon
	VMV, VMIII - Coon's Bluff
	Scattered - Sycamore Creek
Payson	MBI - Webber Creek by Boy Scout Camp; Pine Creek north of Pine
	MBII - East Verde by houses; Fossil Creek
	SYCIII - Rye Creek
	MBIV - Fossil Creek near road 708
	ALDMAPIV - Upper East Verde
	MBV - East Verde west of Highway 87 to Doll Baby Ranch
	MBV - Upper Tonto Creek
	Scattered - lower Webber Creek
Pleasant Valley	ALDMAPI - Workman Creek
	NLCotI* - Turkey Creek, grove by Ranger Station, Cherry/Mo creeks
	MBI - Devil's Chasm Creek, Workman Creek, Canyon Creek at campground
	ALDII - Cherry Creek, Spring Creek by mine

Table 4. (cont.)

Region	Structural type localities
Pleasant Valley (cont.)	MBII - Reynold's Creek, Canyon Creek below OW Ranch
	ALDIII - Cherry Creek
	ALDMAPIV - upper Mule; upper Canyon
	SYC-MBIV - Cherry Creek south of Young at Cherry Creek Ranch
Tonto Basin	CWI - lower Tonto Creek
	MBI - Rock Creek at 3-Bar just below cabin
	CWII - lower Tonto Creek
	MBII - Greenback Valley, Coon Creek, lower Pinto by Anderson Ranch
	VMIII - lower Tonto
	CWIII - lower Tonto
	NHIII** - Gisela area, lower Tonto
	VMIV, VMV, VMVI - lower Tonto
	SCIV - Roosevelt Lake Resort, lower Pinto Creek
	Scattered - Sycamore/Buck Basin creeks

* Narrow-leaf cottonwood (Populus angustifolia).

** Netleaf hackberry (Celtis reticulata)

each of the seven categories (see Methods), as well as the overall ratings, for each of these assessments are given in Table 5. Seven of the riparian situations existing where habitat assessments were conducted were classified as Poor, 13 were classified as Fair, 15 were classified as Moderate, 13 as Good, and 6 were classified as representing riparian habitat in Excellent condition. The sampled areas considered to be in Excellent condition included Devil's Chasm, in the Sierra Ancha Wilderness; Gordon Canyon at approximately 4800 feet, in extremely rough terrain; Reynold's Creek east of the Globe-Young Highway, located within the A-Cross Allotment (has evidently received little grazing pressure); Upper Spring Creek, below Spring Creek Ranch; and Rock Creek, on the Three-Bar Allotment below the cabin.

The average numerical rating for those areas rated as Poor was 1.71. The lowest average scores were recorded in the "Recruitment" and "Invader Species" categories (both 1.1), whereas the categories "Age Class Diversity" (2.4) and "Shrub Frequency" (2.3) had the highest scores in the areas classified as Poor (Table 6).

The average numerical rating of the areas classified as Fair was 2.39. The "Invader Species" category averaged the lowest score (1.6) of the seven categories used. The category measuring the number of trees with a dbh $\geq$8 inches scored at 3.2.

It is interesting to note that "Trees $\geq$8 inches" was the most consistently low scoring category in those areas classified in the Moderate grouping, almost at the level observed in the

Table 5. Riparian Habitat Assessments.

RHA no.	Creek	Beginning elevation	Species/ quadrat	Age class diversity	Shrub frequency	Invader species	No. trees ≥8 in	Reprod. divers.	Recruitment	Mean stability rating	Rating
1	Sycamore at Sunflower	3360	2	3	1	1	2	2	2	1.9	poor
2	Sycamore at USFS work center	3560	4	4	1	4	5	3	3	3.4	good
3	Turkey	5200	3	3	4	2	3	3	4	3.1	good
4	Fish	1800	4	3	3	2	2	2	3	2.7	moder.
5	Cherry	5520	3	4	2	5	5	2	3	3.4	good
6	Cottonwood	3160	3	2	1	2	3	3	3	2.4	fair
7	Alder	4040	2	3	3	2	3	3	2	2.6	fair
8	Workman	6200	3	3	3	5	2	2	3	3.0	moder.
9	Devil's Chasm	3200	5	3	3	3	5	3	3	3.6	excel.
10	East Verde	5800	3	2	5	3	3	3	5	3.4	good
11	Tangle	2740	3	3	1	1	4	3	1	2.3	fair
12	Pinto	2800	2	1	1	2	2	2	1	1.6	poor
13	Pine	6350	3	2	5	5	2	3	4	3.4	good
14	Deer	3440	3	2	4	4	2	4	4	3.3	good
15	Pinto	3140	3	3	1	2	2	3	3	2.4	fair
16	Pine	4850	3	2	4	4	1	2	4	2.9	moder.
17	Marsh	5000	2	4	2	3	2	2	3	2.6	fair
18	Gordon Canyon	4760	5	2	4	4	4	4	5	4.0	excel.
19	Gordon Canyon	5600	3	2	4	1	3	2	3	2.6	fair
20	PB	4040	4	3	3	1	4	3	3	3.0	moder.
21	Houston, Star Valley	4480	2	2	1	1	4	1	1	1.7	poor
22	Marsh	4880	3	3	3	3	2	4	4	3.1	good

Table 5. (cont.)

RHA no.	Creek	Beginning elevation	Species/ quadrat	Age class diversity	Shrub frequency	Invader species	No. trees ≥8 in	Reprod. divers.	Recruitment	Mean stability rating	Rating
23	Cave	2420	1	3	3	1	1	2	1	1.7	poor
24	Reynold's	5400	3	4	5	4	3	4	3	3.7	excel.
25	East Verde	3800	3	2	1	5	1	3	4	2.7	moder.
26	Spring	4100	4	5	2	5	5	3	3	3.9	excel.
27	Fossil	3650	5	5	2	2	4	4	3	3.6	good
28	Queen	2480	2	4	2	2	3	3	3	2.7	moder.
29	Hunter	5800	3	1	3	3	1	5	4	2.9	moder.
30	Ellison	5800	3	4	4	1	4	4	3	3.3	good
31	Haigler	5440	3	2	2	4	3	4	5	3.3	good
32	Webber	5240	3	5	5	1	3	3	2	3.1	moder.
33	Canyon	6430	4	3	4	1	2	2	4	2.9	moder.
34	Bonita	5950	3	5	5	2	4	2	4	3.6	good
35	Cave	3200	2	1	2	1	3	1	1	1.6	poor
36	Christopher	6450	3	1	4	1	1	3	5	2.6	moder.
37	Coon	2677	2	4	3	1	2	2	2	2.3	fair
38	Dude	6160	4	4	4	3	3	2	2	3.1	moder.
39	East Verde	4600	3	2	1	4	3	3	4	2.9	moder.
40	Gordon Canyon	6100	3	3	3	2	4	2	2	2.7	moder.
41	Houston	3440	3	1	2	1	4	3	2	2.3	fair
42	Perley	5600	2	4	5	1	1	1	1	2.1	poor
43	Perley	6250	3	5	5	2	2	2	2	3.0	moder.
44	Pinal	2650	3	2	1	2	4	2	1	2.1	fair
45	Red	2560	4	3	1	1	4	3	2	2.6	fair

Table 5. (cont.)

RHA no.	Creek	Beginning elevation	Species/ quadrat	Age class diversity	Shrub frequency	Invader species	No. trees ≥8 in	Reprod. divers.	Recruitment	Mean stability rating	Rating
46	Rock	2680	5	4	1	3	5	4	3	3.6	excel.
47	Rock	2800.	3	2	2	2	2	2	3	2.3	fair
48	Rock	4400	3	4	2	5	5	3	3	3.6	good
49	Rogers Canyon	3400	3	2	3	2	2	4	4	2.9	moder.
50	Rye	3300	3	3	3	1	3	3	2	2.6	fair
51	Seven Springs	3300	3	1	1	2	5	2	1	2.1	fair
52	Spring	4700	4	3	2	5	5	4	4	3.9	excel.
53	Sycamore at Buck Basin	2278	1	3	3	1	1	1	1	1.6	poor
54	Webber	6000	3	1	4	5	2	3	4	3.1	good

Table 6. RHA summary, grouped rating comparisons.

Commumity factor/description	Average assessment rating/group				
	Poor	Fair	Moderate	Good	Excellent
1. Species/quadrat	1.7	2.8	3.2	3.2	4.3
2. Age class diversity	2.4	2.5	2.9	3.2	3.5
3. Shrub frequency	2.3	1.9	3.2	3.3	2.8
4. Invader species	1.1	1.6	2.5	3.5	4.0
5. Trees $\geq$8 inches	2.0	3.2	2.3	3.4	4.5
6. Reproductive diversity	1.4	2.5	2.7	3.2	3.7
7. Recruitment	1.1	2.2	3.3	3.8	3.5
MEAN RATING	1.71	2.39	2.87	3.37	3.76

Poor areas (2.0). "Recruitment" was the category exhibiting the highest average score (3.3); the overall average numerical rating for the Moderate areas was 2.87 (Table 6).

RHA's rated as Good had an average overall rating of 3.37. None of the categories averaged <3.2; the highest values were observed in the Recruitment category (3.8) (Table 6).

The RHA's in the Excellent category had an average overall rating of 3.76, highest of all the groups but still lower than what might have been expected because of the surprisingly low values computed for the Shrub Frequency factor (Table 6). The Shrub Frequency ratings in the assessments rated as Excellent (2.8) were near those observed in the Poor assessments (2.3). In addition, the average Recruitment rating (3.5) was slightly less than the average in the assessments rated as Good (3.8).

These observations may be the result of the small sample size (n = 6) for areas rated as Excellent. It seems more likely, however, that the inconsistent ratings observed for the Shrub Frequency factor reflect the inadequacy of this particular measure in addressing this particular component of riparian communities. More appropriate measures might have been percent ground cover by riparian shrubs, or some measure of shrub volume. Such procedures would be much more time consuming than the method we employed.

An examination of the average ratings for the assessments categorized as Poor through Excellent (Table 6) reveals that, excepting Shrub Frequency, most of the factors successfully and consistently discriminated between riparian situations of varying

degrees of health or disintegration. The factors which most successfully combined consistency and maximum difference between extreme values were factor 1 (number of riparian tree species per quadrat), factor 4 (number of invader species per quadrat), and factor 6 (reproductive diversity).

Ranking of Reaches

The results obtained when appropriate values were applied to the vegetation, or lack thereof, observed within each of the life zones through which the creeks of the Tonto National Forest flowed (reaches) were sobering (Table 7). Fully 50 percent of the reaches were in a Poor condition during 1980, with an additional 28 percent considered as Fair. Only 15 percent of the reaches ranked as Moderate, 4 percent as Good, and 3 percent as Excellent.

There was a concentration of the lower ranking reaches in the lower elevations. Of the 28 streams flowing through at least two life zones, only two examples (7 percent) were observed where a lower-altitude reach was ranked above the reach at the higher altitude. These were Coon Creek, in which the riparian vegetation of the Lower Sonoran Zone ranked as Fair compared with a Poor ranking in the Upper Sonoran Zone, and Gordon Canyon Creek, where the Upper Sonoran Zone was Moderate, as compared with the Transition Zone, which was Fair. In the remainder of the comparisons (93 percent) the lower reaches were characterized by conditions as poor as or poorer than the upstream sections.

These trends are made more dramatic when comparing reaches within the same life zone. As can be seen in Table 8, 80 percent

Table 7. Riparian condition values on the Tonto National Forest.

Watercourse name	Origin	Life zone[1]	Condition[2]	
Alder	S35,T7N,R8E	LS	0.20	poor[3]
Alder	S35,T7N,R8E	US	0.75	poor
Alder	S8,T9N,R9E	US	2.00	fair
Ash	S28,T5N,R10E	LS	0.79	poor
Ash	S28,T5N,R10E	US	2.28	fair
Ash	S28,T5N,R10E	TR	2.00	fair
Ballantine Creek	S14,T5N,R9E	US	0.32	poor
Bonita	Mogollon Rim	TR	2.39	fair
Boyer Canyon	S36,T6N,R12E	NO SURVEY	NO SURVEY	
Bronco	S20,T7N,R5E	US	0.34	poor
Buck Basin	S16,T5N,R10E	LS	1.00	poor
Camp	S26,T7N,R5E	LS	0.00	poor
Camp	S26,T7N,R5E	US	1.07	poor
Cave	S20,T8N,R5E	LS	1.07	poor
Cave	S20,T8N,R5E	US	2.00	fair
Canyon	S35,T11N,R14E	TR	2.67	moderate
Cherry	S34,T10N,R14E	LS	0.74	poor
Cherry	S34,T10N,R14E	US	2.26	fair
Cherry	S34,T10N,R14E	TR	3.37	good
Christopher	S7,T11N,R13E	TR	2.73	moderate
Colcord	S34,T10-1/2N,R14E	US	1.93	fair
Cold Spring Canyon	S35,T6N,R14E	US	3.08	moderate

Table 7. (cont.)

Watercourse name	Origin	Life zone[1]	Condition[2]	
Coon	S36,T5N,R14E	LS	1.60	fair
Coon	S36,T5N,R14E	US	0.44	poor
Cottonwood	S9,T3N,R12E	LS	0.69	poor
Cottonwood	S9,T3N,R12E	US	1.85	fair
Deadman	S27,T9N,R8E	LS	0.45	poor
Deadman	S27,T9N,R8E	US	0.13	poor
Deer	S16,T8N,R9E	US	2.30	fair
Del Shay	S35,T8N,R12E	LS	1.16	poor
Del Shay	S35,T8N,R12E	US	0.93	poor
Devil's Chasm	S2,T5N,R14E	US	5.00	excellent
Dude	Mogollon Rim	TR	3.17	moderate
East Verde	Mogollon Rim	US	2.19	fair
East Verde	Mogollon Rim	TR	3.42	good
Ellison	Mogollon Rim	TR	1.73	fair
Fish Creek Canyon	S10,T2N,R10E	LS	1.00	poor
Fossil	S13,T12N,R7E	US	2.06	fair
Gordon Canyon	S20,T10-1/2N,R14E	US	3.12	moderate
Gordon Canyon	S20,T10-1/2N,R14E	TR	1.71	fair
Greenback	S16,T6N,R12E	LS	0.77	poor
Greenback	S16,T6N,R12E	US	0.71	poor
Gun	From confluence with Del Shay	LS	0.82	poor

Table 7. (cont.)

Watercourse name	Origin	Life zone[1]	Condition[2]	
Gun	From confluence with Del Shay	US	1.00	poor
Haigler	S10,T10N,R14E	US	2.95	moderate
Haigler	S10,T10N,R14E	TR	2.90	moderate
Hess Canyon	S16,T4N,R16E	LS	0.36	poor
Hess Canyon	S16,T4N,R16E	US	0.07	poor
Horton	Mogollon Rim	TR	2.90	moderate
Houston	S5,T10N,R11E	US	0.91	poor
Houston	S17,T11N,R6E	US	1.68	fair
Hunter	S34,T11N,R13E	TR	1.92	fair
Lime	S33,T9N,R5E	LS	0.53	poor
Lime	S33,T9N,R5E	US	2.40	fair
Marsh	S34,T10N,R13E	US	2.58	moderate
Mineral	S14,T2S,R14E	US	0.10	poor
Mule	S31,T11N,R15E	TR	3.12	moderate
PB	S21,T7N,R14E	US	2.43	moderate
Perley	Mogollon Rim	TR	1.74	fair
Picadilla	S36,T5N,R9E	LS	0.15	poor
Picadilla	S36,T5N,R9E	US	0.72	poor
Pinal	S36,T3N,R14E	LS	1.75	fair
Pine	Mogollon Rim	TR	2.57	moderate
Pinto	S23,T1N,R13E	LS	1.17	fair
Pueblo Canyon	S26,T7N,R14E	US	1.51	fair

Table 7. (cont.)

Watercourse name	Origin	Life zone[1]	Condition[2]	
Queen	S10,T2S,R12E	LS	0.95	poor
Red	S24,T9-1/2N,R5E	LS	1.30	poor
Red	S24,T9-1/2N,R5E	US	1.83	fair
Reno	S2,T6N,R9E	LS	0.10	poor
Reno	S2,T6N,R9E	US	0.86	poor
Reynold's	S21,T6N,R14E	TR	4.51	excellent
Rock (3-Bar)	S9,T4N,R10E	LS	2.02	fair
Rock (3-Bar)	S9,T4N,R10E	US	2.75	moderate
Rock (Superior)	S22,T5N,R9E	LS	1.42	poor
Rock (Superior)	S22,T5N,R9E	US	0.14	poor
Rock (Spring)	S24,T8N,R12E	US	4.31	excellent
Rock (Rye)	S16,T9N,R9E	US	2.00	fair
Rogers Canyon	S3,T1N,R11E	US	2.40	fair
Rye	S28,T10N,R9E	LS	1.18	poor
Rye	S28,T10N,R9E	US	0.98	poor
Salome	S28,T7N,R13E	LS	0.45	poor
Salome	S28,T7N,R13E	TR	3.68	good
Seven Springs Wash	S15,T7N,R5E	US	0.31	poor
Sheep	S15,T7N,R7E	LS	1.10	poor
Slate	S7,T7N,R10E	LS	0.00	poor
Slate	S7,T7N,R10E	US	0.00	poor

Table 7. (cont.)

Watercourse name	Origin	Life zone[1]	Condition[2]
South Fork			
Deadman	S34,T9N,R8E	LS	1.23 poor
Spring	S20,T8N,R13E	US	3.68 good
Squaw	S24,T9N,R4E	LS	0.00 poor
Squaw	S24,T9N,R4E	US	0.55 poor
Sycamore	S10,T5N,R10E	LS	1.00 poor
Sycamore	S25,T7N,R9E	LS	0.61 poor
Sycamore	S25,T7N,R9E	US	1.41 poor
Sycamore	S29,T9N,R7E	LS	2.70 moderate
Tangle	S2,T9N,R5E	LS	2.04 fair
Tangle	S2,T9N,R5E	US	1.59 fair
Tonto	Mogollon Rim	LS	1.01 poor
Tonto	Mogollon Rim	US	NO SURVEY
Tonto	Mogollon Rim	TR	1.90 fair
Turkey	S9,T7N,R12E	TR	1.32 poor
Unnamed Drainage	S23,T4N,R11E	US	0.00 poor
Webber	Mogollon Rim	TR	3.25 moderate
West Fork Pinto	S9,T1N,R12E	US	1.20 poor
West Fork			
Sycamore	S1,T7N,R8E	US	0.83 poor
Wet Bottom	S29,T10N,R7E	LS	2.29 fair
Workman	S33,T6N,R14E	TR	3.00 moderate

Table 7. (cont.)

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[1] LS = Lower Sonoran, approximately ≤3000 feet; US = Upper Sonoran, 3000-5000 feet; TR = Transition Zone, above approximately 5000 feet.

[2] Values based on linear percentages of observed riparian commmunities. Ratings for these communities were obtained via a "Riparian Habitat Assessment" sampling procedure described under "METHODS."

[3] For convenience the condition values can be visualized as occurring in one of five categories: 0 (no riparian vegetation)-1.5 = Poor; >1.5-2.4 = Fair; >2.4-3.3 = Moderate; >3.3-4.3 = Good; >4.3-5.0 = Excellent.

Table 8. Percentage life zone ranking comparisons for riparian vegetation on the Tonto National Forest.

	Life zone		
Rank	Lower Sonoran 10,556 ac	Upper Sonoran 11,312 ac	Transition 4082 ac
Poor	80	46	5
Fair	17	35	33
Moderate	3	13	43
Good	--	2	14
Excellent	--	4	5
	211 ac F,M	6155 I 7E 12,124	3878

of the streams flowing through the Lower Sonoran Zone were in Poor condition, 17 percent were Fair. None were Good or Excellent. The largest percentage of the reaches flowing through the Upper Sonoran Zone were again ranked as Poor (46 percent). Larger percentages of the reaches were ranked as Fair (35 percent) and Moderate (13 percent) than was true of the Lower Sonoran Zone. Six percent of the Upper Sonoran Zone stream reaches were in a Good or Excellent condition.

The condition of the riparian communities characteristic of the Transition Zone reaches was markedly different from that of the two lower reaches. Only 5 percent of these stream reaches ranked as Poor. About the same percentage as that observed in the Upper Sonoran Zone was in the Fair ranking (33 percent), but the Moderate category was represented at a 43 percent level. Fourteen percent of the reaches in the Transition Zone were in a Good condition, and an additional 5 percent were in Excellent condition (Table 8).

Endangered or Special Interest Species

Listed endangered and threatened plant species (Federal Register 1975) encountered during the project included Rumex orthoneurus, Fraxinus anomala var. lowellii (F. lowellii), and Cimicifuga arizonica. Of these, only the Rumex is considered endangered; the only previous documented locality was that of the type collection in the Chiricahua Mountains of southeastern Arizona.

Rumex orthoneurus was observed on the upper part of Reynold's Creek in the Sierra Ancha Mountains, Gila County, altitude approximately 5500 feet. Identification was confirmed

by Dr. Donald J. Pinkava, professor of botany, Arizona State University. Additional material was sent to Europe for further study. A search of the area resulted in a count of roughly 175 individuals. Jerry Davis (Phoenix Office of the Tonto National Forest) informed us that this species had been noted previously (1964) on Workman Creek, and that a small colony also existed on Rose Creek, both creeks in the Sierra Ancha range. The numbers involved in the latter two localities were quite small, totaling <30 plants.

Fraxinus lowellii, or Lowell ash, was observed to be relatively common in proper habitat. This species, listed as threatened, occurs only in Arizona. It was found on north-facing or moist slopes adjacent to creeks but was not often observed as a part of the riparian habitat per se, as was Fraxinus velutina.

Cimicifuga arizonica is found only in central Arizona and has a very limited occurrence. In the Tonto National Forest it is limited to a small patch below the Workman Creek Falls.

Another endangered species known to make riparian contact, but not observed, is Perityle gilensis var. salensis (Laphamia gilensis), a plant of rock clefts in canyons, known from Canyon Lake and Fish Creek. This species is also unique to Arizona.

State and/or federal avian species of special interest observed by us on the Tonto National Forest during 1980 include the Great Egret (Casmerodius albus), Zone-tailed Hawk (Buteo albonotatus), Black Hawk (Buteogallus anthracinus), Bald Eagle (Haliaeetus leucocephalus), and Osprey (Pandion haliaetus). These sightings are summarized in Table 9.

Table 9. Special interest species bird sightings on the Tonto National Forest.

Species[a]	Location
Great Egret	Verde River - heronry across from Box Bar Ranch
Zone-tailed Hawk	Verde River - north of Verde Hot Springs
	Fish Creek - below Apache Trail
	Seven Springs Wash
	Camp Creek - nest along Road 24
	Salt River - Blue Point (probable transient)
	Workman Creek - below Falls
	Houston Creek - 5 miles south of Star Valley
	Ash Creek - 1 mile from El Oso Road
Black Hawk	Devil's Chasm - nest
	Pinto Creek - pair
	West Fork Pinto Creek - pair
	Spring Creek - below Spring Creek Ranch
	Spring Creek - above Flying W Ranch
	Verde River - near Box Bar Ranch
	Cherry Creek - Young to Cherry Creek Ranch

Table 9. (cont.)

Species	Location
Black Hawk (cont.)	East Verde - Road 272, north of Payson
	East Verde - 2 miles east of Highway 87
	Fossil Creek - south of Stehr Lake
Bald Eagle	Salt River - Blue Point, spring and fall
Osprey	East Verde - near confluence with American Gulch

[a] See Appendix for common and scientific bird names.

Bald Eagles and Ospreys were also observed on the lower Salt and Verde rivers during the winter. These sightings were not included in Table 9. Ospreys have previously nested at Granite Reef Dam (Phillips et al. 1964). If the sighting on the East Verde proves to be that of a nesting pair, it would be a significant find.

The river otter (Lutra canadensis), quite rare in Arizona, was not observed by us. However, two credible, though unsubstantiated, reports were received of sightings from Haigler Creek, in 1975, and from the Salt River, near Blue Point in 1980.

DISCUSSION

Both rangeland and riparian habitat quality on the Tonto National Forest has deteriorated in the last few decades. This is not a point of contention for any informed person. Our conversations with ranchers, long-time residents, USDA Forest Service personnel, and others acquainted with and interested in the welfare of the Tonto National Forest have revealed, however, a lack of unanimity about why this deterioration has taken place. Obviously, in the course of a one-year project, it was not possible to control for all the variables that may have affected the observations made. For this reason, if for no other, those disagreeing with the conclusions we have reached and the recommendations we suggest will discredit this report.

The hostile attitudes shared by some special interest groups, and the resultant confrontations, are unfortunate realities threatening, ultimately, the very nature of the Tonto National Forest. Of all recommendations, of all needed changes,

the one that would most facilitate a slowdown or reversal of the current deteriorating trend of the habitat is a heightened level of concern and cooperation, within the USDA Forest Service as well as among those with interest in the land.

As mentioned, we have been exposed to numerous opinions relating to the processes of change. Some of the more prevalent of these include: (1) climatic change, (2) rainfall, and (3) livestock grazing. These will be discussed briefly below.

Climatic Change

Tree ring studies have revealed the historical existence of repeated wet and dry periods occurring in the Southwest. These cycles have not been characterized by rigid, uniform patterns or periods of duration. Indeed, during either type of cycle a period of several years of the opposite extreme of conditions can and often does occur. At any rate, it is the opinion of some that the Southwest has entered into a prolonged period of increased warmth and dryness which started in the late 1800's, and that the lush desert grasslands and verdant, often jungle-like, riparian areas reported on so enthusiastically in the mid-1800's were the end product of a wet, relatively cool period (Hastings and Turner 1965). Therefore, many of the changes that have occurred (such as distribution and composition of plant communities and loss of habitat) were unavoidable and are unalterable.

It is difficult to contend with this position, since it is essentially untestable at least in our lifetimes. Arguments advanced on behalf of some favored causal mechanism (e.g.,

lowered water tables, overgrazing, flash floods) are countered with the explanation or interpretation that, at most, these factors merely expedited the inevitable.

This viewpoint, even if parts of it are true, cannot be accepted. All of us, as joint stewards of the land, must continue to seek solutions while problems remain. To do otherwise, to accept the status quo and allow its government, would be a repudiation of our common mandate.

Rainfall

To many people the most straightforward explanation for the destruction and loss of riparian habitat and the channelization of streambeds is found in the power of flash floods and extended high water flows, such as have occurred in Arizona the previous two winters. This is true, in part. Floodwaters can be destructive, particularly in already weakened systems, but they also encourage regrowth. Riparian communities respond positively, by reproduction, in the aftermath of flood damage. The cottonwood-willow grove near Blue Point on the Salt River is an example. Here the lush undergrowth and streamside vegetation were either removed or destroyed (excepting salt cedar) by the prolonged flooding of early 1980 (Fig. 10). Shortly thereafter, however, vigorous regeneration commenced (Fig. 11), and by summer's end many of the cottonwood seedlings had grown 8-10 feet (Fig. 12), and the area had regained its pre-flood appearance.

Livestock Grazing

Although this project was not designed specifically to determine the impact of grazing on riparian habitat, it is

Figure 10. Salt River, near Blue Point.

Early summer 1980.

Figure 11. Salt River, near Blue Point. Shore edge regeneration, 1980.

Figure 12. Salt River, near Blue Point. Late summer 1980. Undisturbed by grazing, this area responded to flood damage incurred earlier in the year by reproducing vigorously.

nevertheless difficult to drive some 25,000 miles and walk another 1500 miles within the Tonto National Forest boundary without forming some definite opinions. We believe overgrazing by cattle is the single factor most responsible for the continued decline of the quality of riparian habitat in this area. Observations by Davis (1977:61) confirm our position:

> Overgrazing by domestic livestock, in my opinion, is probably the major factor contributing to the failure of riparian communities to propagate themselves. Continued overuse of riparian bottoms eliminates essentially all reproduction as soon as it becomes established. Overstocking and the consequent loss of vegetative cover on the adjacent watersheds is probably the main reason for the frequency of high intensity floods resulting in drastic changes in the density and composition of riparian bottoms.

The evidence supporting such a viewpoint is incontrovertible. Cattle prefer creek bottoms, particularly during the summer at lower elevations (although a few cows, particularly yearlings, were observed in surprisingly steep, rough country). Their physical presence alone is enough to disturb and despoil many areas, but the most devastating effects are wrought by their feeding habits. They truly seem to prefer the tender greens proffered by regenerating riparian trees and vegetation. Areas of flowing water from which cattle are excluded, such as private landholdings, horse pastures, and closed allotments, almost invariably exhibit high levels of vegetative reproduction. The Blue Point grove shown in Figures 10, 11, and 12 was such an area.

Glinski (1977) examined the effects of grazing on the regeneration of sycamore and cottonwood trees in a four-year

study conducted in southeastern Arizona. He found that in areas grazed by cattle, seedlings were "nearly absent," whereas in areas grazed by horses only, seedlings were "abundant."

This is not to suggest that the removal of all cattle would instantly result in a widespread quickening of riparian communities along all the creeks. One of the most prevalent phenomena of the past century has been the channelization of the creeks and rivers of the Southwest, leaving former creek bottoms as dry perched terraces. This causes rainwaters to be carried off rapidly by erosion channels, thus making reproduction by riparian vegetation highly unlikely outside the channel banks. Desertification is now occurring in many such areas in the Tonto National Forest, even where fairly large numbers of mature trees remain (Fig. 6). Glinski (1977) has estimated that as the trees of the raised terraces die, the future maximum width of the riparian forest existing along Sonoita Creek will decrease by 60 percent. Consequences of a similar nature and magnitude will probably take place on many of the creeks of the Tonto National Forest.

Although the riparian habitat of the Lower Sonoran Zone is in worse condition than that of the higher elevations, any remedial procedures would be more effective if initiated first in the upper areas. As the vegetation of the Transition and Upper Sonoran reaches is reestablished, the water flow rates will stabilize. Instead of brief, violent releases of floodwaters, followed by dryness, the streams and riparian communities will hold back the waters and prolong their release. This in turn

would ameliorate downstream conditions, permitting the extension of a healthy system. This is not to suggest, however, that attention should not be directed towards preserving and/or rehabilitating areas of riparian habitat within the Lower Sonoran Zone.

MANAGEMENT SUGGESTIONS, RECOMMENDATIONS AND NEEDS

Not all the following suggestions are made with the expectation that they will be acted upon; there is no significance to the order in which they appear. They are offered in the best interests of the natural resources of the Tonto National Forest.

1. Internal Review

Our discussions with USDA Forest Service personnel at the field, supervisory, and administrative levels indicate a need for policy reformation. Procedural standards are of course necessary, but there are currently too many "Catch-22" dilemmas hampering the implementation of administrative and management goals.

2. Primary Use Areas

Schneegas (1975:315) discussed USDA Forest Service policy towards wildlife. He stated that,

> The Forest Service will...establish wildlife and fish habitat as the primary use on limited areas of land or water which are key to survival for: (1) endangered species, (2) threatened species, (3) species which depend upon National Forest lands for a major portion of their habitat, and (4) other species which depend upon limited areas of seasonal range for survival.

The national distributions of several of the species discussed in this report are completely limited to or largely

restricted within central Arizona. These include the plants Rumex orthoneurus and Cimicifuga arizonica, and several kinds of birds, such as the Zone-tailed Hawk, Black Hawk, and Bald Eagle. Each is dependent upon riparian habitat. A large percentage of the total population of each exists within the Tonto National Forest. The Forest Service must assume an aggressive role in ensuring the continuation of these populations by setting aside, where practicable, such portions of riparian habitat as needed for the sole use of these species.

3. Pasture Resting

Cattle grazing is incompatible with vegetation reproduction in riparian habitat (Davis 1977, Glinski 1977). However, evidence from the Sedow Allotment in the Globe District of the Tonto National Forest indicates that proper rest-rotation grazing procedures allows seedlings to attain sufficient size and strength to survive renewed grazing pressure. At the present time few permittees employ such methods. We recommend that rest-rotation grazing procedures be implemented wherever and whenever possible. We recognize that not all permittees may enjoy the grazing privileges of sufficient pastures to allow for periodic rests of 12-18 months; however, those who so qualify should be given a target date by which time such a plan would be developed in cooperation with the proper district officials of the Tonto National Forest.

4. Improve Range Practices

This is not our area of expertise, but some commonsense changes would lessen the impact of cattle on riparian habitat.

We recommend that USDA Forest Service personnel assist permittees in all possible ways to encourage the use of underutilized parts of pastures. Salt stations should not be permitted on permanent creeks. Additional alternative water sources should be constructed in little-use areas, with salt stations between them to ensure their use. Finally, permittees should be encouraged to employ yearling operations where such operations would be most appropriate in furthering the use of rough or previously underused areas.

5. Habitat Improvement

Quality riparian habitat, particularly below the Transition Zone, is as endangered as any single species mentioned in this report. In most areas trees are not being replaced at the rate they are lost. Implementation of the suggestions listed will help, but in other areas more drastic actions are needed. Natural means of propagation and improvement should be sought after; the simplest and probably most effective means for attaining this goal is to construct low check-dams where channeling has occurred. Examples of such structures, built in the 1930's by the WPA, remain on Dude Creek. More elaborate check-dams would be required on larger creeks.

Immediate benefits would include: (1) the control of flooding, (2) improved wildlife habitat, and (3) additional opportunity for sport-fishing recreation. More long-term benefits relate to riparian habitat. For example, the check-dams would permit deposition of alluvium, over-bank (outside channel)

flooding, and a raising of the water table. Each of these is critical to the maintenance of an extensive and healthy riparian community.

6. National Park

Schneegas (1975:315) discussed USDA Forest Service policies related to nongame birds. These are:

(1) Cooperate with State Conservation Departments as well as with the Fish and Wildlife Service, Bureau of Land Management, and other Federal agencies.
(2) Develop 'appreciative' visitor use of wildlife through programs which encourage bird and animal watching, photography, nature walks, and general observation of all forms of wildlife and fish.
(3) Recognize the importance of the 39 endangered wildlife and fish species found on or near National Forests in the Nation.
(4) Manage and protect wildlife and fish habitat on the National Forests in several ways: through coordination with other land development activities, through direct habitat improvement projects, and through cooperative habitat improvement programs with State Conservation Departments.

We suggest that one way these objectives can best be achieved for a significant portion of remaining high quality habitat is by working toward the establishment of a National Park or National Monument in and around the area of the Sierra Ancha Wilderness and the Sierra Ancha Experimental Forest. If properly designed and developed, such a project would ensure the perpetuation of some of the most pristine riparian communities and large percentages of many of the previously discussed special interest species' populations existing on the Tonto National Forest. Additional attributes justifying or adding to the attractiveness of such a change of status include the scenic qualities of the area, the magnificent vistas available from

various locations, a unique alliance of floristic elements, a system of trails already in place, and proximity to major urban areas. Complementing this major potential for visitor appreciation of unusual plants, animals, and riparian (and other) ecosystems is an unparalleled combination of educational opportunities. A veritable laboratory of cultural phenomena is present on or within view of this area. A short list would include the mining industry, sheep and cattle industry, water and power service developments, and USDA Forest Service projects, activities, and experiments. Additional educational opportunities abound in the geological, archaeological, biological, and historical fields.

Tourism is the second largest industry in the state. Creation of a properly designed Sierra Ancha National Park or National Monument, in addition to ensuring the integrity of a unique area, would garner revenues eclipsing those presently contributing to state and federal coffers, and result in a greater good to more people than that obtained from current onsite uses.

PART TWO

ECOLOGICAL CHARACTERISTICS OF RIPARIAN COMMUNITIES ON THE SALT AND VERDE RIVERS

INTRODUCTION

In Part One of this report we provided information on the extent and condition of riparian habitat on the Tonto National Forest as of 1980. It has been estimated that in the state of Arizona, as a whole, only 15 percent of originally occurring riparian habitat remains (McNatt et al. 1980). The impact of man's developments and activities has been most devastating and debilitating to the riparian communities of the Lower Sonoran Zone, areas of great importance to many species of wildlife and of great intrinsic as well as economic value to man. The Salt and Verde are the two largest and most important rivers within the Lower Sonoran Zone and the Tonto National Forest. Most of the remaining riparian habitat of these rivers exists on the Fort McDowell Indian Reservation; important remnants occurring within the Tonto National Forest are found on the Salt River near Blue Point (Figs. 10-12), and on the Verde River near the Box Bar Ranch (CW II) and the VM III bosque near the Needle Rock area. All these areas are threatened by the proposed construction of Orme Dam and by other human activities.

Provision of recreational opportunities is an important part of the USDA Forest Service's multiple-use management philosophy. However, that does not mean that the value or quality of this or any particular use can continue without affecting the value or quality of the other uses. For example, Aitchison (1977)

observed that the avian community of an area closed to campers changed in diversity and composition after the area was opened to campers. While it was not possible to conduct such a study on the Tonto National Forest the results do serve to demonstrate the need for information about the composition and density of avian, mammalian, amphibian, reptilian, and riparian communities in order to properly evaluate proposed actions or developments and to properly manage the resources entrusted to the USDA Forest Service by congressional charter. Such data are provided for the major riparian communities of the Salt and Verde rivers in the following sections of this report.

DESCRIPTION OF STUDY AREA

The study area was located on the lower Salt and Verde rivers, approximately 25 miles northeast of Phoenix, in Maricopa County, Arizona. Stands of cottonwood-willow, velvet mesquite, and salt cedar riparian vegetation along the river channels and on the first terrace were the subject of the study. The riparian communities occur in narrow strips up to 1.5 miles long and 50 to 700 feet in width, parallel to the rivers and bordering both present and old river channels. Cottonwood-willow and velvet mesquite occurred on both rivers, whereas salt cedar was largely restricted to a small area on the Salt River just above Granite Reef Dam. The cottonwood stands in particular represent remnants of formerly more extensive stands; attrition caused by the death of cottonwood trees and flooding continued during the study period. Trees were lost on both rivers in the February 1980

floods, including an entire 20-acre stand near the USDA Forest Service Granite Reef Campground, in which one of our transects had been located.

The cottonwood-willow communities are characterized by a semi-continuous canopy of cottonwood and willow trees up to 70 feet in height (Fig. 13). The understory is composed predominantly of velvet mesquite mixed with some Baccharis spp. and salt cedar. Arrowweed (Tessaria sericea), desert elderberry (Sambucus mexicana), desert hackberry (Celtis pallida), Condalia spp., and the tree tobacco (Nicotiana glauca) also contributed to the understory vegetation in different cottonwood-willow areas. Small patches of cat-tail (Typha spp.) were present in the Blue Point and Granite Reef stands, both of which were protected from livestock grazing (Figs. 11 and 12).

The velvet mesquite stands are generally found in higher floodplain areas and on the first terrace. Mixed with 10- to 30-foot velvet mesquite trees, to a varying extent, are desert shrubs and trees, including ironwood (Olneya tesota), palo verde, acacia, condalia, bur sage, wolfberry (Lycium spp.), Opuntia spp., saguaro, desert hackberry, and creosote bush (Larrea divaricata). As the velvet mesquite communities yield gradually to desert shrub on higher ground, velvet mesquite densities decrease and tree size is reduced (Figs. 14, 15, and 16).

The single sizable salt cedar area consisted of a nearly pure, dense stand of trees about 15 feet high, with no understory vegetation.

Figure 13. Cottonwood-willow II, Verde River. Note cattle tracks and lack of understory vegetation.

Figure 14. Velvet Mesquite III. Note height and density of trees.

Figure 15. Velvet Mesquite IV. Trees relatively dense but shorter than in Type III.

Figure 16. Velvet Mesquite V. Trees sparse, not tall. Community contains some desert vegetation.

Figure 17. Velvet Mesquite III. After the floods of early 1980, unusually lush growths of herbaceous vegetation occurred.

Weather

Weather conditions during the winter of the study were unusual in that there was greater than normal rainfall on the Salt-Verde watershed, resulting in heavy flooding along the rivers. The floodplain transects were under several feet of water during the latter part of February, and high soil moisture levels may have contributed to an unusually lush growth of herbaceous vegetation and grasses (Fig. 17). It is possible that these conditions altered population density and/or distribution of terrestrial vertebrates either directly by flooding them out, or indirectly by permitting some individuals or species to move into areas that are normally too dry to support them. Phenological events may also have been affected by the unusually high rainfall and water levels.

METHODS

Transects

Transects were established in nearly all accessible, sufficiently-sized stands of relatively homogeneous riparian habitat along the lower Salt and Verde rivers. Each transect was classified according to its community type (based on dominant vegetation) and structural type (based on vertical structure and volume of foliage), based on field observations. These classifications were later checked with quantitative measurements, resulting in reclassification of two transects into different structural types. Although transects at least 2500 feet long are preferable and were established whenever possible, several of the existing stands of riparian vegetation, especially

cottonwood-willow stands, were too small to accommodate a transect of this length. Consequently, it was necessary to use three 1500-foot transects and one 2000-foot transect to obtain a reasonable sample size for two of the rarer community-structural types. Twenty-one transects were established, but since four were lost during the course of the study (three washed away during the February flooding and access to another was blocked by a gravel mining operation), the majority of the data were collected on 17 transects in five different vegetation structural types. For the three major types (CW II, VM III, and VM IV), transects were established in campground areas which received substantial human use, and in less-used noncampground areas, in an effort to assess the effects of recreational use on wildlife. It was necessary to set up transects on Indian reservation land for noncampground velvet mesquite, because all accessible VM III and IV areas on the Tonto National Forest receive considerable recreational use. All transects established, together with their community-structural designations, lengths, locations, and period of data collection, are summarized in Table 10.

Vegetation Sampling

In order to standardize the collection of vegetation data from the transects, each transect was marked off in 500-foot intervals. A 2500-foot transect therefore had five 500-foot intervals, which were divided into left and right sides, yielding ten subplots. Measurements of the various vegetation parameters were made in each of the subplots.

Table 10. Transect characteristics. CG = campground, NCG = non-campground.

Transect	Community-structural type	Length (feet)	Location	Dates used/ reason for loss
TF-01	VM III NCG	2500	Salt River Reservation	Oct 1979-Sept 1980
TF-02	VM IV NCG	2500	Fort McDowell Reservation	Oct 1979-Sept 1980
TF-03*	VM III NCG	2500	Fort McDowell Reservation	Oct 1979-Sept 1980
TF-04	VM III NCG	1500	Salt River Reservation	Oct 1979-Feb 1980/ access barred
TF-05	CW II NCG	3000	Fort McDowell Reservation	Oct 1979-Sept 1980
TF-06	CW III CG	1500	Granite Reef Campground	Oct 1979-Jan 1980/ washed out
TF-07	SC IV	2500	Salt River near Granite Reef	Oct 1979-Sept 1980
TF-08	VM IV NCG	2500	Salt River near Granite Reef	Oct 1979-Sept 1980
TF-09	VM III CG	2500	Coon's Bluff	Oct 1979-Sept 1980
TF-10	CW II NCG	4000	Blue Point	Oct-Nov 1979/by USDA Forest Service/ Mar-Sept 1980
TF-11	VM V CG	2500	Coon's Bluff	Oct 1979-Sept 1980
TF-12	VM V CG	2500	Coon's Bluff	Oct 1979-Sept 1980
TF-13	VM V CG	1500	Coon's Bluff	Oct 1979-Sept 1980
TF-14	CW II NCG	3000	Box Bar (east side)	Oct 1979-Sept 1980

Table 10. (cont.)

Transect	Community-structural type	Length (feet)	Location	Dates used/ reason for loss
TF-15	Revegetation Site	2500	Box Bar (east side)	Oct 1979-Jan 1980/ flooded out
TF-16*	CW II CG	2000	Box Bar (west side)	Oct 1979-Sept 1980
TF-17	VM IV NCG	2500	Box Bar (east side)	Oct 1979-Sept 1980
TF-18	VM III CG	2500	Needle Rock Campground	Oct 1979-Sept 1980
TF-19	VM III NCG	1500	Blue Point	Oct 1979-Nov 1979/ by USDA Forest Service-then flooded out
TF-22	VM IV CG	2500	Coon's Bluff	Dec 1979-Sept 1980
TF-23	VM IV NCG	3000	Box Bar (east side)	Dec 1979-Sept 1980

* Indicates reclassification since the first bimonthly report was submitted.

Percent ground cover of trees and shrubs was estimated by means of line intercepts. At two points in each subplot, a 50-foot line intercept was established 25 feet from the transect line and parallel to it. The length of the line intersected by each tree and shrub species was estimated to the nearest foot. The maximum percent cover for a single species was 100 percent; however, overlapping layers of different plant species were determined separately so that total percent cover was frequently greater than 100 percent. Percent cover of a particular species was calculated for each community-structural type by averaging the number of feet of cover of that species on each of the 50-foot intercept lines in that type, yielding an overall mean and standard deviation for each species. Total percent cover for each community-structural type was calculated using the number of feet covered by all species combined.

Relative foliage volume was estimated using the MacArthur board technique (MacArthur and MacArthur 1961). Foliage volume was estimated at three points within each subplot, i.e., at three points on each side of every 500-foot interval. At each point, the distance to the nearest vegetation within the interval that would cover one-half of a 9 X 18 inch board at each of the following heights was recorded: 6", 2', 5', 10', 15', 20', 25', 30', 40', etc. The formula (0.69/distance) was used to convert distances to relative foliage volumes, yielding a measure of the amount of leaf surface area (square feet) per cubic foot of space.

For calculating foliage height diversity (FHD), foliage was divided into three layers: 0-2 feet (ground cover), 5-20 feet (shrub layer), and >20 feet (tree/canopy layer). FHD was calculated using foliage volumes derived above, and using the Shannon Weaver formula ($-\Sigma p_i \ln p_i$) as an index of diversity, where p_i is the proportion of the total foliage volume represented by a given layer.

Horizontal foliage diversity, or patchiness, was also calculated from foliage volume measurements. To calculate patchiness for a given foliage layer, the average foliage volumes for each subplot were summed. The variance of the subplot volumes was the patchiness value for that layer. Total patchiness is the sum of the patchiness values for each layer. (See Anderson et al. 1977 and Anderson et al. 1978 for a more complete discussion of methods of foliage volume measurements and associated calculations.)

All trees and shrubs within 50 feet of either side of each transect were counted separately by species and height class (greater or less than 10 feet). Counts were recorded in 50 X 500-foot sections (i.e., separately for each subplot), and presence or absence of mistletoe (Phoradendron flavescens) was also recorded. From the count data we calculated the average number of trees per acre for each transect and each community-structural type.

Thirty trees each of cottonwood, willow, and velvet mesquite were tagged for the collection of phenological data, 15 of each species on the Salt River and 15 on the Verde River. These trees

were checked periodically and the timing of phenological events (e.g., leaf initiation, flowering, pod production, etc.) was noted. Unfortunately, February flooding caused the loss of some of the marked trees and loss of tags from others, particularly cottonwoods and willows on the Salt River, so that sample size for these species subsequent to flooding was decreased.

Velvet mesquite pod production was assessed by means of pod counts. Two different methods were employed. Early in the season, when most pods were on trees, the number of pods on a tree was estimated by passing a one-foot diameter hoop into the foliage at head height at each of the four compass points on the tree and counting the pods within the cylinder described by the hoop. Tree height, diameter, and height of the foliage above the ground were also recorded for each sampled tree. The volumes both of the cylinders ($V_c = \pi r^2 h$) and the tree (assuming the tree to be an oblate spheroid, $V_t = 4/3 \pi a^2 b$) were calculated, and the number of pods in the cylinder volume was extrapolated to estimate the number of pods in the entire volume of the tree's foliage. This procedure was applied to at least 15 randomly chosen trees of various sizes. The number of pods was estimated for each separately and the numbers per tree were averaged to yield the mean number of pods per tree for that vegetation type. Later in the season, after pods had dried and fallen to the ground, we employed the second method. All pods on the ground below the tree were counted within a sample plot of known area (5 X 5 feet or a series of 1-foot diameter circles). The diameter of the tree was also recorded, and the number of pods in

the sampled area was extrapolated to obtain an estimate of the number of pods on the total ground area below the tree. Again, at least 15 trees were chosen randomly and used to calculate the mean, as above. A variation of this method was employed in an area where the velvet mesquite tree canopy was continuous and overlapping, such that an individual tree's pods could not be identified. In this case, all pods in ten randomly placed 5 X 5-foot sample plots were counted, and the average number per sample plot was calculated. The number of pods per tree was calculated using the known number of trees in the area obtained from the tree count.

Pods were sampled three times during the season on the same VM IV sample plot (interval 3 of TF-02) in order to monitor changes in pod crop over the production season. We used the first method twice and the ground sample plot method in the latter part of the season. This area was chosen for repeated sampling because it was considered to be typical of velvet mesquite habitat for the study area as a whole. Pod production was also estimated once each in VM V and CW II during the latter part of the season, for the purposes of comparing independent estimates obtained by the two different methods and attempting to assess production in different habitat types.

Reptile and Amphibian Sampling

Reptiles and amphibians were sampled by means of can traps and drift fences. A trap set consisted of two 5-gallon cans dug into the ground to form pitfalls, 100 feet apart, joined by a nylon mesh drift fence. One trap set was placed in a

representative portion of both a campground and a noncampground transect in each of the three major community-structural types (CW II, VM III, and VM IV) for a total of six trap sets. One can open for one 24-hour period was considered a trap day. A total of 428 total trap days were compiled, divided more or less evenly among the different communities.

Each time a trap was checked, the area in the vicinity of the trap set was searched for additional individuals or species. Species sighted in the trap area but not captured were not included in relative densities, but were included in the total number of species for that community-structural type.

The total number of captures and the number of species captured were converted to capture rates (number of captures or number of species captured per 3 trap days) for each species separately and for all species combined (1) at each trap site, (2) for each community-structural type, (3) for lumped campground and noncampground sites, and (4) for all sites combined. The percent of total captures represented by each species was also calculated for each of the four category types.

Capture rate and species capture rates were standardized and then summed to yield a density/diversity index value. A second diversity value was calculated for each of the four category types using the Shannon Weaver index, $-\Sigma p_i \ln p_i$, where p_i was the proportion of total captures represented by a given species.

Small Mammal Censusing

Small mammal populations were sampled by means of snap-trap grids, each grid consisting of two 750-foot parallel lines 50

feet apart. There were 15 trap stations on each line, 50 feet apart, and three traps at each station (two museum specials and one rat trap per station), for a total of 90 traps per grid. Traps were baited with rolled oats and peanut butter and reset each day for 3 consecutive days. Each trap grid set out, therefore, yielded 270 trap nights' of data.

Mammal population data were grouped into two seasons: winter (November through March) and summer (April through October). Trap grids were set out at least once and usually twice a season in each community-structural type in both campground and noncampground areas. However, winter data are incomplete because four trap grids set out on the east side of the Verde River at Box Bar were washed away during flooding, after only one day's data had been obtained in each case. The loss of such a large number of traps sharply curtailed winter trapping efforts until we were able to replace the traps. Consequently, we lack data for the VM IV noncampground type for winter.

Relative rodent densities were expressed as the number of individuals caught per 270 trap nights. Data were summarized by season for each community-structural type, and for campground and noncampground transects.

Bird Censusing

Bird populations were estimated by means of a transect line census method based on Emlen (1971) and modified by us (Anderson et al. 1977). The observer walked the transect recording all birds detected along with their lateral distance from the

transect line (in one of four distance intervals). The peak of distribution of detection points for a species occurred at that distance beyond which detectability of that species decreased. Conversion factors specific to each distance interval were used to extrapolate the peak number of detections over the entire census area. Population density was then expressed as the number of birds per 100 acres. This procedure was applied to each species separately and the species densities were then summed to yield total avian density on a given transect.

Bird densities were computed on a monthly basis, consisting of an average density based on two or three censuses, each by a different observer. Seasonal bird densities were derived by averaging the monthly density figures, and seasonal totals are the sum of the individual species' average densities for the season. Densities were calculated for each transect separately and also for each community-structural type, as a weighted mean of transect densities within that type. All density figures were rounded to the nearest whole number. Bird species which were present in densities of <0.5 per 100 acres for a month or season were not included in density totals.

RESULTS

Percent Ground Cover of Trees and Shrubs

Table 11 summarizes the contribution of each species present in the five community structural types. Total cover was greatest in the SC IV and CW II types (both 99 percent). The seeming discrepancy resulting from a comparison of the percentages of bare ground in these two vegetation types with total cover can be

Table 11. Percent cover of trees and shrubs. CWII = Cottonwood/willow II; VMIII = Velvet mesquite III; VMIV = Velvet mesquite IV; VMV = Velvet mesquite V; SCIV = Salt cedar IV. Standard deviation (SD) in parentheses.

Species	CWII(SD)	VMIII(SD)	VMIV(SD)	VMV(SD)	SCIV(SD)
Prosopis velutina	55(32)	80(22)	41(27)	26(32)	0
Populus fremontii	19(30)	0	0	0	0
Salix gooddingii	13(16)	0	0	0	0
Tamarix chinensis	2(5)	0	3(7)	0	99(3)
Sambucus mexicana	0	<1	0	0	0
Bare ground	16(22)	17(23)	50(26)	68(29)	1(3)
Dead *Prosopis velutina*	<1	1(3)	2(4)	0	0
Dead *Populus fremontii*	2(6)	<1	<1	0	0
Dead *Salix gooddingii*	<1	0	0	0	0
Condalia spp.	<1	4(9)	1(5)	<1	0
Baccharis sergiloides	4(9)	0	0	0	0
Baccharis salicifolia	<1	<1	2(4)	0	0
Tessaria sericea	2(6)				
Celtis pallida	<1	2(7)	0	0	0
Clematis spp.	0	<1	<1	0	0
Cercidium floridum	0	<1	0	1(5)	0
Larrea divaricata	0	<1	2(5)	2(6)	0
Olneya tesota	0	1(9)	0	<1	0

Table 11. (cont.)

Species	CWII(SD)	VMIII(SD)	VMIV(SD)	VMV(SD)	SCIV(SD)
Phoradendron flavescens	2(5)	<1	0	<1	0
Nicotiana glauca	<1	0	0	0	0
Ambrosia deltoidea	0	0	0	2(5)	0
Lycium spp.	0	0	0	1(3)	0
Acacia greggii	0	0	<1	1(4)	0
SAMPLE SIZE	72	80	46	52	10
TOTAL COVER	99	88	51	33	99

explained by the presence of multiple layers of foliage and an understory composed of various plant species occurring in the CW II areas which was lacking in the SC IV type, which was a salt cedar monoculture.

Eleven plant species contributed to the total ground cover in CW II, ten species (not counting dead species) contributed in VM III, seven in VM IV, nine species in VM V (five of which were desert elements), and one species in SC IV.

Foliage Height Diversity (FHD)

Few surprises occur when one examines FHD results (Table 12). As expected, the salt cedar and VM V areas sorted out at the low end of the scale on all transects. The position of Transect 22 was somewhat unexpected, but this transect was located in the heavily used Coon's Bluff recreation area, near the two VM V transects. The fact that the vegetation was more dense in the Type IV area probably resulted in a greater impact and reduction of foliage volume here as opposed to the more sparsely vegetated Type V velvet mesquite areas where such a reduction was less likely to occur. Since there was not a great difference in tree height between the areas, a reduction of FHD was observed.

The velvet mesquite bosque at Needle Rock (TF18), although technically considered a campground area by us, nevertheless retained some areas in a near-natural condition. This fact was reflected in the FHD value, which was at the same level as those of the cottonwood-willow community (Table 12). The cottonwood-willow areas expressed the greatest FHD's.

Table 12. Foliage height diversities (FHD)[1] for riparian communities on the lower Salt and Verde rivers, listed in order of magnitude.

Transect	Vegetation community-structural type	FHD
22	VM[2] IV	0.574
7	SC IV	0.705
13	VM V	0.705
11	VM V	0.798
3	VM III	0.809
1	VM III	0.827
8	VM IV	0.880
9	VM III	0.910
2	VM IV	0.916
23	VM IV	0.948
17	VM IV	0.990
18	VM III	1.045
5	CW II	1.045
16	CW II	1.059
10	CW II	1.066
14	CW II	1.086

[1] FHD intervals used in calculation of values were 6"-2' (first height interval), 5'-15', and 20'-100'.

[2] VM = velvet mesquite, SC = salt cedar, CW = cottonwood-willow.

Volume of Vegetation

As can be seen in Table 13 the two VM V areas were again characterized by low values; however, the two campground VM III areas (TF19 and 18) possessed values at or near those of the Type V structural types. Conversely, the two noncampground VM III areas possessed volumes comparable to those of the cottonwood-willow transects. Salt cedar, which had a very low FHD value, nevertheless had a high volume of vegetation. The greatest volume occurred at TF1Ø, the ungrazed CW II stand near Blue Point on the Salt River.

The distribution of the foliage volume enables one to visualize the structural appearance of the major riparian communities (Fig. 18). The most dramatic comparison is that of campground versus noncampground VM III. Both are similar in terms of the distribution of vegetation above 15 feet. However, as a result of various thinning procedures, the campground VM III areas are more similar to VM IV and V structural types than noncampground VM III from the ground level to 15 feet.

Patchiness

Noncampground CW II exhibited the highest average patchiness values of all areas. SC IV was next highest, followed by noncampground VM III. Campground VM III had the lowest average patchiness values, just less than those of campground VM V (Table 14). The positions of noncampground and campground VM IV may be the result of artificially increased patchiness resulting from the same kinds of habitat disturbance that affected TF-22 (campground VM IV), as discussed above under "Foliage Height Diversity."

Table 13. Estimates of vegetation volume (ft^2/ft^3) for riparian communities on the lower Salt and Verde rivers, listed in order of magnitude.

Transect	Vegetation community-structural type	Volume
11	VM V	0.314
18	VM III	0.494
13	VM V	0.563
9	VM III	0.624
2	VM IV	0.640
8	VM IV	0.641
17	VM IV	0.730
22	VM IV	0.861
23	VM IV	0.989
5	CW II	0.986
7	SC IV	1.089
1	VM III	1.127
14	CW II	1.211
16	CW II	1.391
3	VM III	1.395
10	CW II	1.825

Figure 18. Foliage volume (ft^2/ft^3) profiles of riparian communities on the lower Salt and Verde rivers, Arizona. CG = Campground, NCG = Noncampground.

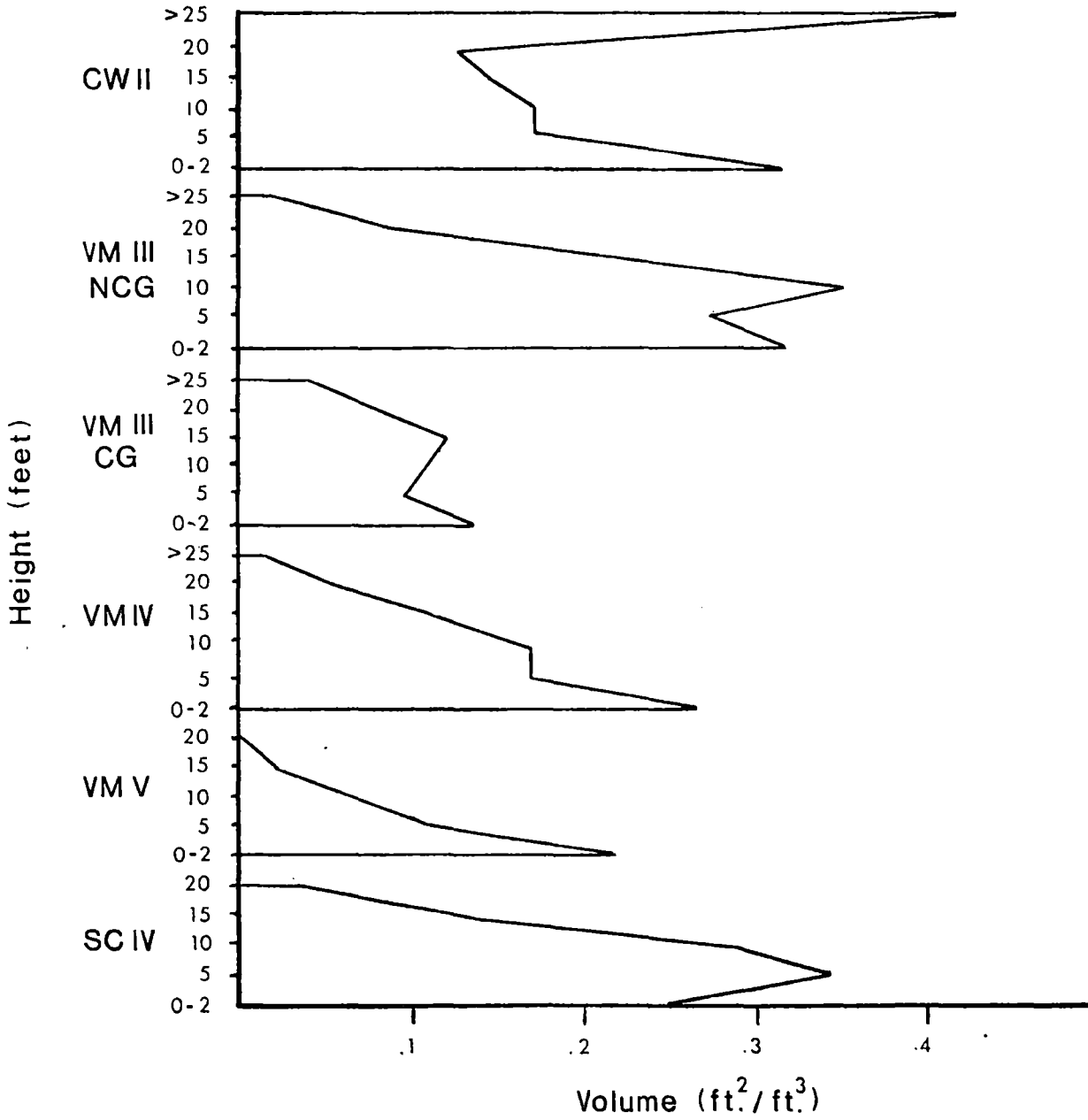

Table 14. Patchiness values for riparian communities on the lower Salt and Verde rivers, listed in order of magnitude.

Vegetation community-structural type	Recreational use	Patchiness
CW II	Noncampground	0.262
SC IV	Noncampground	0.230
VM III	Noncampground	0.162
VM IV	Campground	0.141
CW II	Campground	0.110
VM IV	Noncampground	0.074
VM V	Campground	0.021
VM III	Campground	0.015

Environmental patchiness as measured by this particular index may represent one of the important features used by birds in habitat selection. If so, these results are further evidence of the value of mature and undisturbed stands of native vegetation.

Tree Counts

Table 15 summarizes the results of tree counts by community-structural types. The greatest density of perennial plants and the greatest tree (>10 feet) density were found on the CW III transect, followed by SC IV. These high density communities had the fewest species, while VM IV, with the lowest total density, had the highest number of species.

There were four times as many cottonwoods and 30 times as many willows in CW III as in CW II, and about the same density of salt cedars was found in CW III as in the SC IV community. However, this community had only five species, fewer than any other except salt cedar. It was unusual also in that none of the trees was infested with mistletoe, and it was the only community where no velvet mesquite was present.

CW II, which was characterized by a relatively depauperate understory, had fewer total perennial plants than any community but VM IV, despite the fact that it had a high number of species. Its tree density was intermediate; although broad-leaf density was less than in CW III, the overall density of velvet mesquite was greater in this community than in any of the velvet mesquite-dominated communities. Mistletoe was present in 56 percent of the cottonwoods, 15 percent of the willows, and only 1 percent of the velvet mesquite.

Table 15. Average number of trees and shrubs/acre, lower Salt and Verde rivers.

Species	Community-structural type					
	SC IV	VM III	VM IV	VM V	CW II	CW III
Cottonwood <10 ft	0.0	0.0	0.0	0.0	0.7	0.3
Cottonwood >10 ft	0.0	0.0	0.04	0.0	3.0	12.2
Cottonwood with mistletoe >10 ft	0.0	0.0	0.0	0.0	3.8	0.0
Dead cottonwood	0.0	0.3	0.06	0.0	1.5	0.9
Willow <10 ft	0.0	0.0	0.0	0.0	0.1	5.2
Willow >10 ft	0.0	0.0	0.0	0.0	2.9	72.9
Willow with mistletoe >10 ft	0.0	0.0	0.0	0.0	0.5	0.0
Dead willow	0.0	0.0	0.0	0.0	0.1	0.6
Velvet mesquite <10 ft	0.0	30.8	54.5	14.5	42.4	0.0
Velvet mesquite >10 ft	1.7	77.5	45.9	12.7	73.0	0.0
Velvet mesquite with mistletoe >10 ft	0.0	3.4	2.2	1.9	0.9	0.0
Dead velvet mesquite	0.0	2.8	0.6	0.07	0.8	0.0
Salt cedar <10 ft	35.5	0.0	0.0	0.0	2.5	48.5
Salt cedar >10 ft	142.5	0.0	0.0	0.0	1.1	126.9
Dead salt cedar	0.0	0.0	0.0	0.0	0.0	2.9
Desert elderberry <10 ft	0.0	0.1	0.08	0.0	0.4	2.0
Ash >10 ft	0.0	0.0	0.04	0.0	0.0	0.0

Table 15. (cont.)

Species	Community-structural type					
	SC IV	VM III	VM IV	VM V	CW II	CW III
Desert hackberry <10 ft	0.0	0.0	0.2	0.0	0.9	0.0
Desert hackberry >10 ft	0.0	5.0	0.0	0.0	0.02	0.0
Netleaf hackberry <10 ft (Celtis reticulata)	0.0	0.0	0.0	0.0	0.2	0.0
Acacia <10 ft	0.0	0.7	0.0	6.0	0.0	0.0
Acacia >10 ft	0.0	0.0	0.0	0.3	0.0	0.0
Ironwood >10 ft	0.0	0.1	0.0	0.0	0.0	0.0
Palo verde <10 ft	0.0	0.7	0.3	0.8	0.2	0.0
Palo verde >10 ft	0.0	0.2	0.4	0.8	0.2	0.0
Bur sage (Ambrosia deltoidea)	0.0	0.0	0.2	96.7	0.0	0.0
Condalia spp.	0.0	27.6	11.1	6.6	0.7	0.0
Hymenoclea spp.	0.0	0.0	0.0	4.8	0.0	0.0
Creosote bush	0.0	6.1	7.1	11.6	0.0	0.0
Wolfberry	0.0	0.8	1.2	4.0	0.2	0.0
Tree tobacco	0.0	1.1	0.0	0.0	14.4	9.9
Opuntia spp.	0.0	0.04	0.7	2.9	0.0	0.0
Saguaro (Carnegiea gigantea)	0.0	0.0	0.1	1.0	0.0	0.0

VM III was second to CW II in velvet mesquite density, and the proportion of >10- to <10-foot velvet mesquites (2.51) was greater in this than in any other community, reflecting its characteristic of continuous velvet mesquite canopy cover. This community had the greatest density of trees of the VM types. Sharing with VM IV the highest number of species (12), it had a relatively dense and diverse understory of both desert and riparian shrubs. Four percent of the velvet mesquites were infested with mistletoe.

VM IV had the lowest total density of perennial plants and the second lowest density of trees. The density of velvet mesquites was intermediate among the velvet mesquite communities. It shared the high number of species with VM III, reflecting the incursion of more desert species than in the canopied velvet mesquite.

VM V with only 15.4 trees per acre had the lowest tree density, and also had the lowest density of velvet mesquite among the velvet mesquite communities, reflecting its position highest above the floodplain, grading into desert. It ranked third in total density of perennials due to intermixture of many small desert shrubs, particularly bur sage and creosote bush, among the short, sparsely distributed velvet mesquites. The number of species was low, since no riparian shrub or broadleaf species were present. Thirteen percent of the trees had mistletoe.

SC IV had a high tree density and high total density of perennials, but only two species were present. This community was an essentially monotypic stand of salt cedar with no understory and only an occasional velvet mesquite.

Phenology

Tables 16-18 summarize phenological data for the three major riparian tree species in the study area. Overall means are based on 30 trees, and means for each river are based on 15 trees, through February 1980, at which time several marked trees were lost. Beginning in March, sample sizes for cottonwoods and willows on the Salt River were 3 and 0 respectively, and 14 and 15 respectively on the Verde River.

The leaves of both broadleaf species began to change color in early November 1979, while velvet mesquite leaves remained green. None of the three species completely dropped their leaves during the winter of 1979-80, the broadleafs retained about 20 percent foliage and the velvet mesquites about 40 percent. The greatest percentage of leaf drop (>90 percent) was for Verde River cottonwood trees.

Cottonwoods began flowering in late January, prior to leafing out, and nearly all were flowering and leafing by mid-February (Table 16). At this time, willows were just beginning to put out leaves, and, in contrast to cottonwoods, flowered two to three weeks after they began putting out new leaves, around early March (Table 17). Cottonwoods were in full leaf in mid-March, willows by late March. Cottonwoods began dispersing seeds in early April.

Velvet mesquites showed essentially no change from early winter to April, although there may have been a small amount of leaf production in mid-March, possibly related to the heavy February rainfall. Most began leafing in early April and began

Table 16. Phenological data, lower Salt and Verde rivers, cottonwood (*Populus fremontii*).

Date	Observation
1979	
Nov 15-25	Beginning of leaf color change
Nov 20-30	Beginning of leaf drop
1980	
Jan 25-28	20.3 ± 19.5 percent leaves retained; 6.6 percent flowering
Jan 25	31.3 ± 19.9 percent leaves retained; 6.6 percent flowering (Salt)
Jan 28	9.3 ± 11.6 percent leaves retained; 6.6 percent flowering (Verde)
Feb 6-13	91 percent flowering; 88 percent leaf initiation
Feb 6	80 percent flowering; 92 percent leaf initiation (Salt)
Feb 13	100 percent flowering; 78 percent leaf initiation (Verde)
Mar 4	93 percent full leaf
Mar 20	100 percent full leaf
Apr 7	100 percent in fruit; cotton dispersing

Table 17. Phenological data, lower Salt and Verde rivers, willow (*Salix gooddingii*).

Date	Observation
1979	
Nov 15-25	Beginning of leaf color change
Nov 20-30	Beginning of leaf drop
1980	
Jan 25-28	20 ± 22 percent leaves retained; none flowering
Jan 25	20 ± 23 percent leaves retained (Salt)
Jan 28	21 ± 21 percent leaves retained (Verde)
Feb 6-13	37 percent leaf initiation; none flowering
Feb 6	17 percent leaf initiation; none flowering (Salt)
Feb 13	53 percent leaf initiation; none flowering (Verde)
Mar 4	100 percent leaf initiation; 87 percent flowering
Mar 20	100 percent full leaf

Table 18. Phenological data, lower Salt and Verde rivers, velvet mesquite (*Prosopis velutina*).

1980	
Jan 25-28	40 ± 24 percent leaves retained
Jan 25	42 ± 25 percent leaves retained (Salt)
Jan 28	37 ± 22 percent leaves retained (Verde)
Feb 6-13	No change
Mar 4	No change
Mar 18	No change (33 percent initiation?)
Apr 4-10	63 percent leaf initiation
Apr 4	93 percent leaf initiation (Salt)
Apr 10	20 percent leaf initiation (Verde)
Apr 25	80 percent leaf initiation; 15 percent flowering
May 5	100 percent full leaf; 75 percent flowering; no pods (Verde)
Jun 4	87 percent flowering; 53 percent initiating pod production (Salt); pods green, 2-6" long
Jul 4	None flowering; 87 percent with pods (3-8" long, dry) (Verde)
Aug 7	80 percent with pods (4-8" long, dry) (Salt)
Aug 26	100 percent with pods (4-8" long, dry) (Verde)

flowering from late April to early May, when they were in full leaf. A large proportion of the trees continued to flower into early June, by which time pod production had begun. New pods were being produced into early August (Table 18).

Pod Counts

Table 19 summarizes the results of pod counts in three community-structural types. Although they were obtained by different methods, pod count results were reasonably consistent. The estimated numbers of pods per tree obtained from three different sample plots and over a three-month period were well within one order of magnitude; the standard deviations overlapped. There was a substantial degree of variability among trees with regard to pod production in all the sampled communities. The differences among communities in pod production per acre reflect different densities of velvet mesquite trees in the three communities, indicating differences in production per tree to a lesser extent and only in one community.

The estimated number of pods per tree was greatest early in the season, and declined consistently over the course of the summer in the VM IV plot. This decline probably resulted from decreased pod production and/or consumption of pods by wildlife and livestock. Pod production per tree in VM V appears to be less than that of VM IV, since when sampled at a date intermediate between two VM IV samples, the resulting estimate of number of pods/tree was less than that obtained earlier and later in VM IV.

Table 19. Velvet mesquite pod production, lower Salt and Verde rivers, 1980.

Community/ structural type	Date	Mean pods/tree	Mean pods/acre	Pounds of pods/ acre
VM V	7 August	2712	70,512	427
VM IV	4 July	10,044	803,440	4,869
	26 August	6653	532,206	3,225
	29 September	594	47,520	288
CW II*	26 September	2715	8,182,926	49,593

* Data obtained from CW II represent the pod production estimate for VM III.

CW II had a large estimated number of pods per tree late in the season, about five times as great as for VM IV during the same time period (Table 19). This may be related to three factors. First, the proportion of >10-foot trees was higher in cottonwood-willow than in either of the velvet mesquite communities (see Table 15), and larger trees presumably produce more pods. Second, the CW II sample area was lower on the floodplain and immediately adjacent to a backwater area; greater moisture in this area may stimulate pod production. Finally, the CW II area was protected from livestock grazing, so one of the factors potentially causing a decrease in the standing crop of pods late in the season did not apply here. However, it must be noted that the VM V plot was also protected from grazing.

Reptiles and Amphibians

Tables 20(a-f) summarize species occurrence and relative densities of amphibians and reptiles as determined from trap data. Nine species (six reptiles and three amphibians) were captured in traps, and an additional three species (of snakes) were sighted in the vicinity of the traps but never captured. In addition to those listed in Tables 20(a-d), three other species were observed in different parts of the study area; western diamond-back rattlesnake (Crotalus atrox), coachwhip (Masticophis flagellum), and bullfrog (Rana catesbeiana).

Capture rates were relatively low, 0.40 per three trap days for all species together over all communities (Table 20d), with a maximum of 0.97 in campground CW II (Table 20c). Because of low capture rates, statistical analyses of the results were

Table 20a. Species occurrence and relative densities of reptiles and amphibians in VM III.

Species	Noncampground			Campground			Total		
	Number captured	Capture rate	Percent of total captures	Number captured	Capture rate	Percent of total captures	Number captured	Capture rate	Percent of total captures
Desert spiny lizard (Sceloporus magister)	3	0.16	100	0	0.00	0	3	0.16	30
Chihuahuan whiptail (Cnemidophorus exsanguis)	0	0.00	0	0	0.00	0	0	0.00	0
Western whiptail (C. tigris)	0	0.00	0	0	0.00	0	0	0.00	0
Tree lizard (Urosaurus ornatus)	0	0.00	0	0	0.00	0	0	0.00	0
Western blind snake (Leptotyphlops humilis)	0	0.00	0	0	0.00	0	0	0.00	0
Banded sandsnake (Chilomeniscus cinctus)	0	0.00	0	0	0.00	0	0	0.00	0
Red-spotted toad (Bufo punctatus)	0	0.00	0	2	0.08	29	2	0.05	20
Woodhouse toad (Bufo woodhousei)	0	0.00	0	5	0.20	80	5	0.11	50
Couch spadefoot toad (Scaphiopus couchii)	0	0.00	0	0	0.00	0	0	0.00	0
TOTAL	3	0.16	100	7	0.28	100	10	0.32	100

Table 20b. Species occurrence and relative densities of reptiles and amphibians in VM IV.

Species	Noncampground			Campground			Total		
	Number captured	Capture rate	Percent of total captures	Number captured	Capture rate	Percent of total captures	Number captured	Capture rate	Percent of total captures
Desert spiny lizard	2	0.09	29	2	0.07	50	4	0.08	36
Chihuahuan whiptail	0	0.00	0	1	0.04	25	1	0.02	9
Western whiptail	2	0.09	29	0	0.00	0	2	0.04	18
Tree lizard	2	0.09	29	0	0.00	0	2	0.04	18
Western blind snake	0	0.00	0	0	0.00	0	0	0.00	0
Banded sandsnake	1	0.04	15	0	0.00	0	1	0.02	9
Red-spotted toad	0	0.00	0	1	0.04	25	1	0.02	9
Woodhouse toad	0	0.00	0	0	0.00	0	0	0.00	0
Couch spadefoot toad	0	0.00	0	0	0.00	0	0	0.00	0
TOTAL	7	0.31	102	4	0.15	100	11	0.22	99

Table 20c. Species occurrence and relative densities of reptiles and amphibians in CW II.

Species	Noncampground			Campground			Total		
	Number captured	Capture rate	Percent of total captures	Number captured	Capture rate	Percent of total captures	Number captured	Capture rate	Percent of total captures
Desert spiny lizard	4	0.14	25	8	0.41	42	12	0.25	34
Chihuahuan whiptail	1	0.03	6	2	0.10	11	3	0.06	9
Western whiptail	1	0.03	6	0	0.00	0	1	0.02	3
Tree lizard	3	0.10	19	0	0.00	0	3	0.06	9
Western blind snake	0	0.00	0	1	0.05	5	1	0.02	3
Banded sandsnake	0	0.00	0	0	0.00	0	0	0.00	0
Red-spotted toad	3	0.10	19	0	0.00	0	3	0.06	9
Woodhouse toad	2	0.07	13	8	0.41	42	10	0.21	29
Couch spadefoot toad	2	0.07	13	0	0.00	0	2	0.04	6
TOTAL	16	0.54	101	19	0.97	100	35	0.72	102

Table 20d. Total species occurrence and relative densities of reptiles and amphibians.

Species	Noncampground			Campground			Total		
	Number captured	Capture rate	Percent of total captures	Number captured	Capture rate	Percent of total captures	Number captured	Capture rate	Percent of total captures
Desert spiny lizard	9	0.13	34	10	0.14	33	19	0.13	34
Chihuahuan whiptail	1	0.01	4	3	0.04	10	4	0.03	7
Western whiptail	3	0.04	12	0	0.00	0	3	0.02	5
Tree lizard	5	0.07	19	0	0.00	0	5	0.04	9
Western blind snake	0	0.00	0	1	0.01	3	1	0.01	2
Banded sandsnake	1	0.01	4	0	0.00	0	1	0.01	2
Red-spotted toad	3	0.04	12	3	0.04	10	6	0.04	11
Woodhouse toad	2	0.03	8	13	0.18	43	15	0.11	27
Couch spadefoot toad	2	0.03	8	0	0.00	0	2	0.01	4
TOTAL	26	0.36	101	30	0.41	99	56	0.40	101

Table 20e. Capture data for reptiles and amphibians. NCG = noncampground, CG = campground.

	VM III			VM IV			CW II			Grand Total		
	NCG	CG	Total	NCG	CG	Total	NCG	CG	Total	NCG	CG	Total
Number of trap days	56	76	132	68	82	150	88	58	146	212	216	428
Total number of captures	3	7	10	7	4	11	16	19	35	26	30	56
Number of species captured	1	2	3	4	3	6	7	4	8	8	6	9
Number captured per 3 trap days	0.16	0.28	0.23	0.31	0.15	0.22	0.56	0.98	0.72	0.37	0.42	0.39
Number of species captured per 3 trap days	0.05	0.08	0.07	0.21	0.11	0.12	0.24	0.21	0.16	0.11	0.08	0.06
Density/Diversity Index value	0.21	0.36	0.30	0.52	0.26	0.34	0.80	1.19	0.88	0.48	0.50	0.45
Species diversity ($-\Sigma p_i \ln p_i$)	0.000	0.598	1.030	1.352	1.040	1.635	1.841	1.120	1.755	1.852	1.294	1.801

Table 20f. Capture rates (N/3 trap days) of reptiles and amphibians in campground (CG) and noncampground (NCG) vegetation types.

Species	VM IV		VM III		CW II		Effect of campground
	CG	NCG	CG	NCG	CG	NCG	
Desert spiny lizard	0.07	0.09	0.00	0.16	0.41	0.14	None
Chihuahuan whiptail	0.04	0.00	0.00	0.00	0.10	0.03	Positive?
Western whiptail	0.00	0.09	0.00	0.00	0.00	0.03	Negative
Tree lizard	0.00	0.09	0.00	0.00	0.00	0.10	Negative
Western blind snake	0.00	0.00	0.00	0.00	0.05	0.00	---------
Banded sandsnake	0.00	0.04	0.00	0.00	0.00	0.00	---------
Red-spotted toad	0.04	0.00	0.08	0.00	0.00	0.10	None
Woodhouse toad	0.00	0.00	0.20	0.00	0.41	0.07	Positive
Couch spadefoot toad	0.00	0.00	0.00	0.00	0.00	0.07	Negative?
TOTAL	0.15	0.31	0.28	0.16	0.97	0.54	

inappropriate. The desert spiny lizard (Sceloporus magister) was the species captured most often, and it also had the broadest distribution, being captured at five of the six trap sites. Red-spotted toads (Bufo punctatus) with the third highest relative density (0.04) were captured at three of the sites, whereas other species had relatively restricted distributions of capture, occurring at only one or two of the sites. However, none of the species captured at only two sites was captured within a single community-structural type, e.g., only in VM IV (both campground and noncampground). Although they were relatively rarely captured, tree lizards (Urosaurus ornatus) had the broadest habitat distribution, having been either captured or sighted at all six sites and on all transects.

The cottonwood-willow community had the highest relative densities of both reptiles and amphibians, with both campground and noncampground sites equalling or exceeding all other sites in the number of species captured, overall capture rate, and species diversity (as calculated with the Shannon Weaver [1949] index; Table 20e). Eight of the nine species captured over the entire study period occurred in cottonwood-willow, and the noncampground site alone had seven (Table 20c). Although relative density of all species combined was greatest at the campground site, captures there included only four species, with two of these captured in relatively large numbers. In contrast, seven different species were captured at the noncampground site and their relative densities were more evenly distributed, so that the diversity index for this site is higher than that of the campground site.

VM IV was second to cottonwood-willow in overall number of captures, number of species captured (six), and species diversity (Table 20e). The capture rate for this community was approximately equal to that of VM III. The noncampground VM IV site had higher values than the campground site for all variables measured.

While capture rate in VM III was close to the value for VM IV, only three species were captured, with one species accounting for half the total number of captures (Table 20a). Consequently, the diversity value for this community was low. VM III was the only community in which the campground site had higher values for all measured variables than the noncampground site (Table 20e).

When results from all communities were pooled, campground areas had a slightly higher capture rate than noncampground (Table 20d). Noncampground areas, however, had a higher number of species and more even distribution of captures among species, resulting in a higher overall diversity value (Table 20e).

A comparison of capture rates in campground versus noncampground areas in the major community types is presented in Table 20f. We reiterate the dangers of making conclusive statements based on small sample sizes (in this study the total number of reptiles and amphibians captured was 56), however we may tentatively suggest the effect of recreational development on some species of reptiles and amphibians. Results indicate that the desert spiny lizard is probably not adversely affected by campground development, the greatest density occurring in campground CW II. The western whiptail (Cnemidophorus tigris)

and tree lizard (Urosaurus ornatus) populations, however, appear to be negatively impacted in campground areas. The Woodhouse toad (Bufo woodhousei) is the only species which was clearly observed in higher numbers in campground riparian habitat (VM III and CW II; Tables 20d and 20f).

Small Mammal Sampling

Nine species of mammals were captured during the year in all communities, seven each in winter and summer. One of the winter species (Peromyscus maniculatus) occurred only in the revegetation site, an area subsequently lost during the floods. It is likely that this species would have been present during the summer period as well, which would have increased the summer total to eight species.

Total densities between seasons were fairly consistent except in CW II (Tables 21 and 22). Densities of Peromyscus eremicus were six times greater during the winter in CW II than during the summer. The next greatest change in density occurred in VM IV, which increased from two (winter) to seven (summer) captures/270 trap nights. This increase was the result of the increased activity of Perognathus penicillatus during the summer, and the movement of Sigmodon hispidus into the area in response (we believe) to the lush grass and herbaceous growth resulting from the winter rains and floods (Fig. 17).

Number of species observed in the major community-structural types (excluding the revegetation site) varied from one (salt cedar, winter) to four (salt cedar and cottonwood-willow, summer). However, one of the four species captured during the summer in CW II included Mephitis mephitis.

Table 21. Winter 1980 small mammal densities (captures/270 trap nights).

Species	Community-structural type					
	Revegetation site	SC IV	VM V	VM IV	VM III	CW II
Round-tailed ground squirrel (*Spermophilus tereticaudus*)	1.0	_	1.0	0.5	-	-
Desert pocket mouse (*Perognathus penicillatus*)	1.0	-	1.0	1.0	0.5	0.6
Merriam kangaroo rat (*Dipodomys merriami*)	4.0	-	-	-	-	-
Cactus mouse (*Peromyscus eremicus*)	22.0	7.0	-	-	1.3	31.8
Deer mouse (*Peromyscus maniculatus*)	1.0	-	-	-	-	-
Hispid cotton rat (*Sigmodon hispidus*)	-	-	-	-	0.8	-
White-throated woodrat (*Neotoma albigula*)	1.0	-	-	0.5	-	2.4
Number of species	6	1	2	3	3	3
Number of captures	30.0*	7.0	2.0	2.0	2.6	34.8

*Captures/180 trap nights.

Table 22. Summer 1980 small mammal densities (captures/270 trap nights).

Species	Community-structural type				
	SC IV	VM V	VM IV	VM III	CW II
Round-tailed ground squirrel	-	1.0	-	-	-
Desert pocket mouse	1.0	2.5	4.0	1.0	1.3
Western harvest mouse (*Reithrodontomys megalotis*)	1.0	-	-	-	-
Cactus mouse	4.0	-	-	-	5.8
Hispid cotton rat	-	-	3.0	1.3	-
White-throated woodrat	2.0	0.5	-	0.3	0.5
Striped skunk (*Mephitis mephitis*)	-	-	-	-	0.3
Number of species	4	3	2	3	4
Number of captures	8.0	4.0	7.0	2.6	7.9

The comparison of campground versus noncampground in the velvet mesquite and cottonwood-willow communities was of interest. The number of species in both community types was greatest in the campground areas during the winter. Campground densities were either greater than (velvet mesquite) or comparable to (cottonwood-willow) those of noncampground. The reverse was true during the summer. Density and number of species were greater in the noncampground areas in velvet mesquite, and densities were greater in noncampground in the cottonwood-willow community. Number of species in cottonwood-willow were the same, but one of the species included was Mephitis mephitis in the campground areas (Tables 23 and 24).

Bird Censusing

A total of approximately 115 species was detected while censusing the transects of the Salt and Verde rivers. Seasonal avian densities for each major community and structural type are presented in Tables 25-29. Totals are summarized in Table 30.

VM V had the highest average density of birds two out of five seasons (winter and spring), as did SC IV (summer and late summer; Table 30). Species contributing most heavily to the totals in VM V included Mourning Dove (Zenaida macroura) and wintering sparrows (Brewer Sparrow, Spizella breweri; White-crowned Sparrow, Zonotrichia leucophrys; Tables 26 and 27), whereas nonresident breeding species were of great importance in SC IV (White-winged Dove, Zenaida asiatica; Yellow-breasted Chat, Icteria virens; Brown-headed Cowbird, Molothrus ater) during the

Table 23. Winter 1980 small mammal densities (captures/270 trap nights), campground/noncampground comparisons.

	Velvet mesquite		Cottonwood-willow	
Species	Campground	Noncampground	Campground	Noncampground
Desert pocket mouse	1.0	-	1.0	-
Cactus mouse	2.5	-	22.0	31.0
Hispid cotton rat	1.0	0.5	-	-
White-throated woodrat	-	-	4.0	-
TOTAL	4.5	0.5	27.0	31.0*
Number of species	3	1	3	1

*Captures/180 trap nights.

Table 24. Summer 1980 small mammal densities (captures/270 trap nights), campground/noncampground comparisons.

	Velvet mesquite		Cottonwood-willow	
Species	Campground	Noncampground	Campground	Noncampground
Desert pocket mouse	1.5	0.5	1.5	1.0
Cactus mouse	-	-	3.0	8.5
Hispid cotton rat	-	2.5	-	-
White-throated woodrat	-	0.5	-	1.0
Striped skunk	-	-	0.5	-
TOTAL	1.5	3.5	5.0	10.5
Number of species	1	3	3	3

Table 25. Avian densities by community-structural type, October-November 1979. R = resident, WR = winter resident, SR = summer resident, T = transient.

Species	VM III	VM IV	VM V	CW II	CW III	SC IV	Status
Great Blue Heron[a]	-[b]	-	-	1	-	-	R
Sharp-shinned Hawk	0[c]	0	0	-	1	-	WR
Cooper Hawk	0	1	-	0	0	-	R
Red-tailed Hawk	-	0	-	-	-	-	R
Harris Hawk	-	1	0	1	-	-	R
Prairie Falcon	-	-	0	-	-	-	WR
American Kestrel	-	-	0	1	-	-	R
Gambel Quail	3	148	4	78	76	44	R
White-winged Dove	-	-	-	1	-	-	SR
Mourning Dove	6	4	81	6	-	-	R
Inca Dove	-	-	-	2	-	-	R
Roadrunner	0	1	-	1	3	-	R
Great Horned Owl	0	-	-	-	-	-	R
Anna Hummingbird	0	-	-	4	21	-	WR
Common Flicker	4	4	18	9	7	-	R
Gila Woodpecker	21	9	4	15	15	15	R
Yellow-bellied Sapsucker	3	1	-	0	-	-	WR
Ladder-backed Woodpecker	4	3	1	9	8	3	R
Ash-throated Flycatcher	2	-	1	0	2	-	SR
Black Phoebe	1	-	-	1	-	-	R
Say Phoebe	-	-	-	0	-	-	T
Gray Flycatcher	1	-	-	1	-	-	WR
Common Raven	0	0	-	0	-	-	R
Bridled Titmouse	0	-	-	2	-	-	WR
Verdin	13	12	7	19	30	5	R
Brown Creeper	1	-	-	1	-	-	WR
House Wren	5	2	1	7	29	18	WR
Bewick Wren	16	11	3	14	39	18	R
Cactus Wren	3	12	20	7	5	6	R
Long-billed Marsh Wren	-	-	-	3	12	-	R
Cañon Wren	3	0	-	5	5	-	R
Rock Wren	-	1	-	-	-	-	T
Curve-billed Thrasher	0	0	4	1	5	-	R
Crissal Thrasher	1	7	0	3	2	2	R
Hermit Thrush	-	-	-	-	3	-	T
Western Bluebird	-	-	-	1	-	-	WR
Blue-gray Gnatcatcher	0	1	-	0	-	-	WR
Black-tailed Gnatcatcher	5	3	3	1	-	-	R
Golden-crowned Kinglet	-	-	-	-	3	-	T

Table 25. (cont.)

Species	VM III	VM IV	VM V	CW II	CW III	SC IV	Status
Ruby-crowned Kinglet	46	16	11	52	109	11	WR
Phainopepla	1	0	4	1	-	-	WR
Loggerhead Shrike	2	4	4	3	1	-	R
Starling	2	5	3	5	-	-	R
Hutton Vireo	-	0	-	0	2	-	WR
Solitary Vireo	-	0	-	-	-	-	T
Orange-crowned Warbler	4	-	-	11	12	-	WR
Yellow-rumped Warbler	12	3	1	9	54	5	WR
Black-throated Gray Warbler	-	1	-	1	-	-	WR
Western Meadowlark	-	-	2	-	-	-	WR
Brown-headed Cowbird	-	-	-	1	-	-	SR
Cardinal	6	3	-	4	6	3	R
House Finch	1	4	1	8	8	-	R
Lesser Goldfinch	0	-	-	-	-	-	R
Green-tailed Towhee	0	3	-	1	-	-	WR
Rufous-sided Towhee	0	3	-	0	5	-	WR
Abert Towhee	29	64	18	57	62	145	R
Vesper Sparrow	7	1	-	-	-	-	T
Lark Sparrow	-	10	-	-	-	-	T
Black-throated Sparrow	-	6	24	-	-	-	R
Dark-eyed Junco	20	6	2	2	-	-	WR
Brewer Sparrow	-	1	59	-	-	-	WR
White-crowned Sparrow	19	63	190	3	8	53	WR
Lincoln Sparrow	0	-	-	2	-	-	T
Song Sparrow	-	-	-	6	9	-	R
TOTAL DENSITY	241	411	466	360	542	328	
NUMBER OF SPECIES	29	33	24	42	29	13	

[a] See Appendix for common and scientific bird names.
[b] Dashed lines indicate that the species was not observed during the season in this community-structural type.
[c] Zeros indicate that the species was observed in this community-structural type, but calculated densities were <1.0/100 acres.

Table 26. Avian densities by community-structural type, December 1979-February 1980. See Table 25 for status abbreviations.

Species	VM III	VM IV	VM V	CW II	CW III	SC IV	Status
Great Blue Heron[a]	–[b]	–	–	1	0[c]	–	R
Sharp-shinned Hawk	–	0	0	1	–	–	WR
Cooper Hawk	0	0	0	–	0	–	R
Red-tailed Hawk	–	0	0	1	–	–	R
Harris Hawk	0	–	0	1	–	–	R
Bald Eagle	–	–	–	0	–	–	R
Osprey	–	–	–	0	–	–	WR
Prairie Falcon	–	–	0	–	–	–	WR
American Kestrel	0	0	–	–	–	–	R
Gambel Quail	4	34	6	17	5	26	R
Mourning Dove	10	1	52	1	–	12	R
Inca Dove	2	–	–	–	2	–	R
Screech Owl	0	–	–	0	–	–	R
Great Horned Owl	–	0	–	3	0	–	R
Anna Hummingbird	2	0	1	17	13	1	WR
Common Flicker	1	3	7	4	7	–	R
Gila Woodpecker	6	5	6	14	16	0	R
Yellow-bellied Sapsucker	2	–	–	3	3	–	WR
Ladder-backed Woodpecker	1	4	2	19	26	0	R
Ash-throated Flycatcher	1	–	1	–	–	–	SR
Black Phoebe	1	–	–	1	3	–	R
Say Phoebe	0	0	–	1	–	–	T
Gray Flycatcher	3	1	1	3	3	–	WR
Common Raven	0	0	1	–	–	–	R
Bridled Titmouse	–	–	–	6	–	–	WR
Verdin	10	6	6	14	15	–	R
Brown Creeper	3	–	–	–	–	–	WR
House Wren	0	–	–	2	13	4	WR
Bewick Wren	10	6	5	24	26	15	R
Cactus Wren	2	2	8	6	7	–	R
Long-billed Marsh Wren	–	–	–	2	8	–	R
Cañon Wren	1	0	–	3	8	–	R
Curve-billed Thrasher	0	–	1	2	3	–	R
Crissal Thrasher	0	3	0	4	–	2	R
Western Bluebird	1	6	2	8	1	–	WR
Mountain Bluebird	–	0	–	–	–	–	T
Blue-gray Gnatcatcher	–	1	–	5	10	–	WR
Black-tailed Gnatcatcher	1	1	1	–	–	–	R
Ruby-crowned Kinglet	36	18	15	72	142	3	WR
Phainopepla	8	14	6	4	–	–	WR
Loggerhead Shrike	1	2	1	–	–	–	R
Starling	0	4	3	12	1	–	R
Hutton Vireo	1	1	–	4	3	–	WR
Solitary Vireo	1	–	0	2	–	–	T
Orange-crowned Warbler	1	0	0	17	40	–	WR
Yellow-rumped Warbler	8	3	4	31	55	4	WR
Black-throated Gray Warbler	0	–	0	5	–	–	WR
Western Meadowlark	0	0	22	–	–	–	WR
Cardinal	2	5	1	1	7	–	R
House Finch	8	1	26	4	3	–	R
Lesser Goldfinch	0	–	0	3	3	–	R
Green-tailed Towhee	0	2	0	–	–	–	WR
Rufous-sided Towhee	–	0	–	–	–	–	WR
Brown Towhee	–	0	–	–	–	–	T
Abert Towhee	34	55	7	45	73	101	R
Vesper Sparrow	1	0	–	–	–	–	T
Lark Sparrow	–	7	6	–	–	–	T
Sage Sparrow	–	–	3	–	–	–	WR
Black-throated Sparrow	–	3	10	–	–	–	R
Dark-eyed Junco	38	8	19	–	–	–	WR
Gray-headed Junco	0	–	–	–	–	–	T
Chipping Sparrow	3	–	–	–	–	–	WR
Brewer Sparrow	3	3	102	–	–	12	WR
White-crowned Sparrow	60	71	214	1	–	50	WR
Lincoln Sparrow	0	–	0	3	3	–	T
Song Sparrow	0	–	0	2	10	–	R
TOTAL DENSITY	266	270	539	369	509	230	
NUMBER OF SPECIES	33	28	30	41	29	11	

[a] See Appendix for common and scientific bird names.
[b] Dashed lines indicate that the species was not observed during the season in this community-structural type.
[c] Zeros indicate that the species was observed in this community-structural type, but calculated densities were <1.0/100 acres.

Table 27. Avian densities by community-structural type, March-April 1980. See Table 25 for status abbreviations.

Species	VM III	VM IV	VM V	CW II	SCIV	Status
Great Blue Heron[a]	-[b]	0[c]	-	9	-	R
Cooper Hawk	0	0	0	0	-	R
Red-tailed Hawk	0	0	0	0	-	R
Zone-tailed Hawk	-	-	-	1	-	T
Harris Hawk	0	0	-	-	-	R
Black Hawk	-	-	-	1	-	SR
Bald Eagle	-	-	-	0	-	R
Osprey	-	-	-	0	-	WR
American Kestrel	-	0	-	1	-	R
Gambel Quail	4	23	1	25	110	R
Spotted Sandpiper	-	-	-	0	-	WR
White-winged Dove	0	1	-	2	-	SR
Mourning Dove	10	26	53	20	38	R
Roadrunner	0	0	-	1	-	R
Barn Owl	-	-	-	0	-	R
Great Horned Owl	-	-	-	0	-	R
Black-chinned Hummingbird	2	3	-	12	-	SR
Costa Hummingbird	2	1	0	0	-	T
Anna Hummingbird	8	2	-	2	-	WR
Belted Kingfisher	-	-	-	0	-	WR
Common Flicker	1	2	3	1	-	R
Gila Woodpecker	5	5	4	13	1	R
Yellow-bellied Sapsucker	1	-	-	-	-	WR
Ladder-backed Woodpecker	4	5	3	17	3	R
Western Kingbird	-	1	0	-	-	SR
Ash-throated Flycatcher	7	4	7	9	-	SR
Black Phoebe	0	0	-	1	-	R
Say Phoebe	0	0	1	-	-	T
Hammond Flycatcher	-	-	-	1	-	T
Gray Flycatcher	1	0	0	1	-	WR
Western Wood Pewee	-	-	-	1	-	T
Vermilion Flycatcher	0	2	1	1	-	R
Rough-winged Swallow	-	0	-	0	-	R
Cliff Swallow	-	-	-	0	-	T
Common Raven	0	0	-	2	-	R
Verdin	5	5	7	6	-	R
House Wren	1	-	-	-	-	WR
Bewick Wren	2	3	4	11	12	R
Cactus Wren	1	0	5	0	-	R
Curve-billed Thrasher	-	-	1	-	-	R
Crissal Thrasher	0	3	1	0	-	R
American Robin	-	0	-	-	-	WR
Hermit Thrush	-	-	-	-	6	T

Table 27. (cont.)

Species	VM III	VM IV	VM V	CW II	SCIV	Status
Western Bluebird	4	1	-	0	-	WR
Blue-gray Gnatcatcher	-	-	-	1	-	WR
Black-tailed Gnatcatcher	-	1	-	-	-	R
Ruby-crowned Kinglet	14	5	6	31	-	WR
Phainopepla	9	21	7	-	-	WR
Starling	0	23	24	21	-	R
Bell Vireo	4	0	-	2	3	SR
Solitary Vireo	-	0	-	3	-	T
Orange-crowned Warbler	-	0	-	1	-	WR
Virginia Warbler	1	-	-	-	-	T
Lucy Warbler	61	81	14	83	26	SR
Yellow Warbler	0	-	-	9	-	SR
Yellow-rumped Warbler	6	1	-	21	3	WR
Black-throated Gray Warbler	-	1	-	-	-	T
Common Yellowthroat	-	-	-	0	-	SR
Yellow-breasted Chat	1	-	-	2	-	SR
Wilson Warbler	-	-	-	1	-	T
Summer Tanager	-	-	-	2	-	SR
Hooded Oriole	0	-	-	2	-	SR
Northern Oriole	2	1	-	6	-	SR
Brown-headed Cowbird	1	9	1	6	18	SR
Western Meadowlark	-	0	16	-	-	WR
Cardinal	7	7	1	8	29	R
House Finch	6	5	57	11	-	R
Lesser Goldfinch	13	5	16	23	23	SR
Lawrence Goldfinch	-	-	-	3	-	SR
Green-tailed Towhee	1	0	0	-	1	WR
Brown Towhee	-	-	-	1	-	T
Abert Towhee	28	43	15	50	55	R
Vesper Sparrow	1	-	19	-	-	T
Lark Sparrow	-	-	5	-	-	T
Dark-eyed Junco	9	2	3	1	-	WR
Black-throated Sparrow	-	0	3	-	-	R
Chipping Sparrow	2	-	13	-	-	WR
Brewer Sparrow	-	-	58	-	-	WR
White-crowned Sparrow	7	22	87	-	-	WR
Lincoln Sparrow	7	2	8	3	-	T
Song Sparrow	1	0	-	8	23	R
TOTAL DENSITY	239	316	442	437	349	
NUMBER OF SPECIES	36	32	31	46	15	

[a] See Appendix for common and scientific bird names.
[b] Dashed lines indicate that the species was not observed during the season in this community-structural type.
[c] Zeros indicate that the species was observed in the community-structural type, but calculated densities were <1.0/100 acres.

Table 28. Avian densities by community-structural type, May-July 1980. See Table 25 for status abbreviations.

Species	VM III	VM IV	VM V	CW II	SC IV	Status
Great Blue Heron[a]	-[b]	-	-	2	-	R
Green Heron	0[c]	-	-	-	-	R
Turkey Vulture	-	-	-	1	-	R
Cooper Hawk	0	0	0	3	-	R
Red-tailed Hawk	-	0	0	-	-	R
Harris Hawk	0	0	-	4	-	R
American Kestrel	-	0	-	-	-	R
Gambel Quail	21	82	49	24	132	R
White-winged Dove	13	27	6	20	159	SR
Mourning Dove	46	64	120	24	44	R
Yellow-billed Cuckoo	0	2	-	2	-	SR
Roadrunner	-	1	2	1	-	R
Great Horned Owl	0	0	-	4	-	R
Lesser Nighthawk	0	-	1	-	-	SR
Black-chinned Hummingbird	0	-	2	13	-	SR
Anna Hummingbird	1	1	-	3	-	WR
Common Flicker	1	1	0	1	-	R
Gila Woodpecker	3	5	5	14	-	R
Ladder-backed Woodpecker	6	4	9	11	-	R
Western Kingbird	-	2	4	1	-	SR
Wied Crested Flycatcher	8	9	13	24	-	SR
Ash-throated Flycatcher	7	8	12	6	-	SR
Black Phoebe	0	-	-	-	-	R
Hammond Flycatcher	1	-	-	1	-	T
Gray Flycatcher	-	-	0	-	-	WR
Western Flycatcher	-	1	-	-	-	T
Western Wood Pewee	1	-	-	-	-	T
Vermilion Flycatcher	-	0	-	2	-	R
Rough-winged Swallow	0	-	-	-	-	SR
Common Raven	-	0	0	2	-	R
Verdin	17	12	30	6	2	R
House Wren	-	-	-	1	-	WR
Bewick Wren	7	5	0	16	-	R
Cactus Wren	1	0	21	-	-	R
Mockingbird	0	-	-	-	-	R
Curve-billed Thrasher	-	0	2	-	-	R
Crissal Thrasher	1	2	-	2	-	R
Black-tailed Gnatcatcher	0	4	1	-	-	R
Ruby-crowned Kinglet	1	-	0	1	-	WR
Phainopepla	6	17	-	2	-	R
Loggerhead Shrike	-	0	-	-	-	R
Starling	0	5	3	5	-	R

Table 28. (cont.)

Species	VM III	VM IV	VM V	CW II	SC IV	Status
Bell Vireo	10	3	-	11	7	SR
Solitary Vireo	1	1	-	1	-	T
Warbling Vireo	1	-	0	1	-	T
Orange-crowned Warbler	1	-	-	-	-	WR
Lucy Warbler	112	97	25	74	27	SR
Yellow Warbler	1	1	-	34	-	SR
Yellow-rumped Warbler	1	-	2	2	-	WR
Black-throated Gray Warbler	2	0	0	2	-	WR
Townsend Warbler	2	-	-	1	-	T
Northern Waterthrush	-	-	-	1	-	T
MacGillivray Warbler	-	-	-	1	-	T
Common Yellowthroat	0	-	-	1	-	SR
Yellow-breasted Chat	5	11	-	9	162	SR
Wilson Warbler	2	2	1	2	-	T
Hooded Oriole	6	0	-	13	-	SR
Northern Oriole	11	12	8	28	-	SR
Great-tailed Grackle	0	0	-	-	-	SR
Brown-headed Cowbird	10	36	7	7	95	SR
Bronzed Cowbird	-	1	-	-	-	SR
Western Tanager	1	-	-	2	-	T
Summer Tanager	2	1	-	21	-	SR
Cardinal	11	19	2	15	21	R
Blue Grosbeak	1	3	0	1	16	SR
House Finch	7	11	13	11	4	R
Lesser Goldfinch	2	7	-	6	17	R
Lawrence Goldfinch	1	-	-	1	-	SR
Abert Towhee	45	70	10	92	153	R
Lark Sparrow	-	0	0	1	-	T
Chipping Sparrow	-	-	2	-	-	WR
Brewer Sparrow	-	-	8	-	-	WR
White-crowned Sparrow	-	-	5	1	17	WR
Song Sparrow	0	-	-	15	106	R
TOTAL DENSITY	378	527	369	509	962	
DENSITY 10% DOVES	326	446	255	469	779	
NUMBER OF SPECIES	39	34	27	55	15	

[a] See Appendix for common and scientific bird names.
[b] Dashed lines indicate that the species was not observed during the season in this community-structural type.
[c] Zeros indicate that the species was observed in this community-structural type, but calculated densities were <1.0/100 acres.

Table 29. Avian densities by community-structural type, August-September 1980. See Table 25 for status abbreviations.

Species	VM III	VM IV	VM V	CW II	SC IV	Status
Great Blue Heron[a]	-[b]	0[c]	-	1	-	R
Turkey Vulture	-	0	-	5	-	R
Sharp-shinned Hawk	-	-	-	0	-	WR
Cooper Hawk	1	1	0	0	1	R
Red-tailed Hawk	0	0	-	0	-	R
Swainson Hawk	-	-	-	0	-	T
Zone-tailed Hawk	-	-	-	1	-	T
Harris Hawk	1	0	0	4	-	R
American Kestrel	0	0	0	1	-	R
Gambel Quail	91	146	115	91	209	R
White-winged Dove	5	3	-	7	-	SR
Mourning Dove	18	30	110	26	-	R
Yellow-billed Cuckoo	1	-	-	1	-	SR
Roadrunner	2	5	2	2	3	R
Barn Owl	0	-	-	-	-	R
Great Horned Owl	1	0	-	1	-	R
Anna Hummingbird	-	1	-	1	-	WR
Belted Kingfisher	-	-	-	0	-	WR
Common Flicker	1	1	3	5	-	R
Gila Woodpecker	11	5	5	25	1	R
Ladder-backed Woodpecker	8	5	6	12	-	R
Western Kingbird	2	1	0	3	12	SR
Cassin Kingbird	-	0	-	7	-	T
Wied Crested Flycatcher	8	8	1	20	-	SR
Ash-throated Flycatcher	12	18	3	8	-	SR
Black Phoebe	0	-	-	1	-	R
Say Phoebe	-	0	-	-	-	T
Willow Flycatcher	2	-	-	2	-	T
Western Flycatcher	1	-	-	1	-	T
Western Wood Pewee	-	-	-	1	-	T
Vermilion Flycatcher	-	0	-	-	-	R
Common Raven	-	0	-	0	-	R
Verdin	27	22	17	23	53	R
White-breasted Nuthatch	-	-	-	1	-	WR
House Wren	1	1	-	13	6	WR
Bewick Wren	6	6	1	21	6	R
Cactus Wren	1	2	25	3	6	R
Long-billed Marsh Wren	-	-	-	1	-	R
Cañon Wren	0	-	-	-	-	R
Rock Wren	-	-	-	1	-	R
Mockingbird	1	-	0	2	-	R

Table 29. (cont.)

Species	VM III	VM IV	VM V	CW II	SC IV	Status
Curve-billed Thrasher	0	1	3	0	6	R
Crissal Thrasher	4	5	1	2	4	R
Blue-gray Gnatcatcher	1	0	1	1	6	WR
Black-tailed Gnatcatcher	-	0	1	-	-	R
Ruby-crowned Kinglet	0	-	-	1	-	WR
Cedar Waxwing	-	-	-	1	-	T
Phainopepla	3	1	0	2	-	R
Loggerhead Shrike	1	1	2	1	-	R
Starling	2	1	2	5	-	R
Bell Vireo	8	1	-	5	6	SR
Solitary Vireo	-	-	-	1	-	T
Warbling Vireo	1	-	1	5	-	T
Orange-crowned Warbler	1	-	-	3	-	WR
Nashville Warbler	-	-	-	2	-	T
Virginia Warbler	-	1	-	1	-	T
Lucy Warbler	3	8	1	9	18	SR
Yellow Warbler	1	0	-	6	3	SR
Black-throated Gray Warbler	-	-	-	1	-	WR
Townsend Warbler	-	-	-	1	-	T
MacGillivray Warbler	1	-	-	7	12	T
Common Yellowthroat	-	-	-	4	-	SR
Yellow-breasted Chat	1	1	-	8	13	SR
Wilson Warbler	1	2	0	15	12	T
Western Meadowlark	-	-	0	-	-	WR
Hooded Oriole	3	1	-	2	-	SR
Northern Oriole	4	2	-	6	5	SR
Brown-headed Cowbird	0	-	-	-	-	SR
Western Tanager	1	1	0	2	-	T
Summer Tanager	3	1	0	27	-	SR
Cardinal	14	9	0	24	22	R
Black-headed Grosbeak	1	2	0	2	-	T
Blue Grosbeak	2	8	0	2	18	SR
Lazuli Bunting	-	-	0	1	-	T
House Finch	2	2	8	3	15	R
Lesser Goldfinch	0	0	-	0	-	R
Green-tailed Towhee	-	1	-	1	-	WR
Brown Towhee	0	-	-	-	-	T
Abert Towhee	47	89	9	60	198	R
Vesper Sparrow	0	4	1	-	-	T
Lark Sparrow	2	4	12	1	-	T
Black-throated Sparrow	0	1	28	-	-	R
Sage Sparrow	-	0	-	-	-	T
Chipping Sparrow	-	-	0	-	-	WR

Table 29. (cont.)

Species	VM III	VM IV	VM V	CW II	SC IV	Status
Brewer Sparrow	1	4	12	-	-	WR
White-crowned Sparrow	-	-	-	1	-	WR
Lincoln Sparrow	-	-	-	1	-	WR
Song Sparrow	1	0	-	5	18	R
TOTAL DENSITY	309	406	369	510	653	
NUMBER OF SPECIES	46	40	25	67	24	

[a] See Appendix for common and scientific bird names.
[b] Dashed lines indicate that the species was not observed during the season in this community-structural type.
[c] Zeros indicate that the species was observed in this community-structural type, but calculated densities were <1.0/100 acres.

Table 30. Summary of seasonal avian species richness and density estimates (N/100 acres) in the major vegetation structural types of the lower Salt and Verde rivers. Density is in parentheses.

Season	VM III Number of species	VM IV Number of species	VM V Number of species	CW II Number of species	SC IV Number of species
Fall	29(241)	33(411)	24(466)	42(360)	13(328)
Winter	33(266)	28(270)	30(539)	41(369)	11(230)
Spring	36(239)	32(316)	31(442)	46(437)	15(349)
Summer	39(378)	34(527)	27(369)	55(509)	15(962)
Late summer	46(309)	40(406)	25(369)	67(510)	24(653)
AVERAGE	37(287)	33(386)	27(437)	50(437)	16(504)

summer period (Table 28). The Gambel Quail (Lophortyx gambelii) was the most numerous species in SC IV during late summer (Table 29).

CW II had the greatest number of species in each of the five seasons, averaging nearly 13 species more than the next richest community. Of the velvet mesquite structural types, Type III (tall, dense trees) had more species than the other two types four out of five seasons (winter, spring, summer, late summer; Table 30).

Total Vertebrates

Vertebrate richness totals were similar in VM IV and VM III (42 and 45 species, respectively) and greatest in CW II (67 species), as measured during the summer period (Table 31). The increasing values of such environmental features as foliage volume and percent ground cover found as one moves from VM IV to VM III to CW II evidently results in a concomitant increase in the desirability or suitability of riparian habitat to amphibians, small mammals, and birds. The same number of reptiles were observed in VM IV and CW II. It is obvious that the greatest diversities for all classes of land vertebrates existed within the cottonwood-willow community.

DISCUSSION AND MANAGEMENT RECOMMENDATIONS

Previous work related to the riparian vegetation of the Tonto National Forest is all but nonexistent. Except for a brief note by Johnson and Simpson (1971), scattered references in The Birds of Arizona (Phillips et al. 1964), an Orme Dam impact statement for the then Bureau of Reclamation by Ohmart (1976),

Table 31. Number of vertebrate species per vegetation type, summer 1980.

Vertebrate group	Community-structural type		
	VM IV	VM III	CW II
Amphibians	1	2	3
Reptiles	5	1	5
Mammals	2	3	4
Birds	34	39	55
TOTAL	42	45	67

and a few other minor publications, the nature of the characteristics of this important resource remained little known.

The most relevant of the above works is that of Ohmart (1976). Since the majority of the remaining habitat on the lower reaches of the Salt and Verde rivers is on Indian lands, much of Ohmart's work was carried out in these areas. Similar techniques were employed to sample small mammals, but a comparison of capture rates is not valid. Small mammal population levels and fluctuations are not understood by experts; numbers fluctuate in response to numerous known and unknown factors. Density estimates should be viewed as broad and relative indices at best. However, species occurrence can be compared with slightly more confidence. Species trapped by Ohmart during 1974-75 in cottonwood-willow, velvet mesquite, and salt cedar areas that were not trapped during 1979-80 in similar areas include Perognathus baileyi, Onychomys torridus, Mus musculus, Ammospermophilus harrisii, and Spermophilus variegatus. Species trapped during 1979-80 that were not observed during the earlier period (excluding Mephitis mephitis) were Peromyscus maniculatus and Reithrodontomys megalotis.

All of these species, except Perognathus baileyi, can be identified easily. We offer no explanation for its possible absence during 1979-80. All Perognathus appearing even slightly nontypical were keyed out, always to P. penicillatus. The last three of these species listed for the 1974-75 period were relatively scarce and may simply have been missed by chance during the present study. Also, some of the species are more

typical of rocky hillsides or desert areas. These species may have abandoned the riparian zone because of the unusually lush conditions which existed, as previously noted.

The most interesting comparison, however, was that of Onychomys and Sigmodon. During 1974-75 Onychomys was common and widespread, whereas Sigmodon was restricted to marsh (Ohmart 1976). However, during 1979-80 Onychomys was not observed at all, whereas Sigmodon was common and widespread. It seems likely that the herbaceous growth, as illustrated in Figure 17, was viewed as an acceptable alternative habitat by Sigmodon and was so utilized, but this growth was not suitable for Onychomys.

Bird censusing techniques employed by Ohmart and his staff differed from those of this project; nonetheless the great value of riparian habitat to birds was evident in their results. They mentioned the similarity of avian densities and species richness in velvet mesquite areas, regardless of percent ground cover in the areas. This observation could be applied generally to the results of this study as well (Tables 25-29).

Bird communities should not be considered just from the standpoint of numbers only. There are a number of bird species which are restricted to certain types of riparian habitat and an examination of the distribution of these species helps to reveal the value of certain vegetation types. Ten obligate riparian bird species are listed in Table 32, along with densities in noncampground VM IV, three VM III areas, and CW II. It is quite evident that the Needle Rock velvet mesquite stand (TF18), described earlier as an area most reminiscent of a pristine

Table 32. Numbers (N/100 acres) of some obligate riparian bird species[a], with emphasis on the values observed in the Needle Rock velvet mesquite bosque.

Species	Velvet mesquite Type III				
	VM IV[b]	TFØ1	TFØ9	Needle Rock	CW II
Cooper Hawk	-	-	-	1	1
Yellow-billed Cuckoo	1	1	-	<1	2
Black-chinned Hummingbird	-	1	-	-	10
Anna Hummingbird	-	-	-	3	2
Bell Vireo	2	-	1	40	8
Yellow Warbler	1	1	2	1	27
Yellow-breasted Chat	-	-	1	20	6
Hooded Oriole	1	1	1	25	10
Northern Oriole	11	10	16	10	26
Summer Tanager	-	8	-	-	21
TOTAL RIPARIAN OBLIGATES	16	22	21	100	113
TOTAL DENSITY	416	323	306	518	559
DENSITY WITH 10% DOVES	368	262	247	489	514
DENSITY OF GAMBEL QUAIL	80	6	10	-	61
NUMBER OF SPECIES	24	22	25	24	42

[a] See Appendix for common and scientific bird names.

[b] Data for noncampground areas, TFØ2, TF17, TF23.

velvet mesquite bosque and structural type, while not different in terms of species richness from other velvet mesquite areas, was vastly superior in terms of its value to these obligate riparian bird species. Of particular interest was the density of singing Bell Vireos (Vireo bellii), a species showing alarming population declines in much of the southwestern United States.

If the Needle Rock velvet mesquite stand were to be further developed for intensive campground purposes (involving the reduction of foliage volume below ten feet and the thinning of trees) an 88 percent reduction of the obligate riparian species densities listed in Table 32 could be expected. Species such as the Cooper Hawk (Accipiter cooperii), Yellow-billed Cuckoo (Coccyzus americanus), Anna Hummingbird (Calypte anna), Bell Vireo, Yellow-breasted Chat, and Hooded Oriole (Icterus cucullatus) would probably disappear. Other species would experience population reductions as well, including woodpeckers, flycatchers, and the Lucy Warbler (Vermivora luciae) and Abert Towhee (Pipilo aberti).

Recommendations

1. Those areas that remain on the Tonto National Forest that are not currently developed should be given protective status from any and all types of physical disturbance. This is particularly true for cottonwood-willow stands, and especially the velvet mesquite bosque near Needle Rock. This is one of the last remnants and the finest example of a true velvet mesquite bosque left on the Salt and Verde river

systems. This community-structural type is on the verge of extinction and should be zealously protected.

2. No estimates or techniques for aging riparian trees are currently available, but it is quite evident that a long period of time has elapsed since successful reproduction of these trees has occurred on the Salt and Verde rivers. Reproduction was widespread after the overbank flooding that occurred in 1980. However, after cattle were reintroduced that summer, all unprotected seedlings were eaten. We recommend that rest-rotation procedures be implemented to allow the establishment of whatever opportunistic reproductive activity may naturally occur and/or to allow artificially planted trees an opportunity to mature without grazing pressure.
3. During the last few years the trees of the lower Verde River have suffered a tremendously high mortality rate (see McNatt et al. 1980). It is apparent that a major reason for this decline is the irregular and extremely low water release rates from Bartlett Dam. We recommend that release rates be maintained at a minimum level of 200 cfs to maintain the remaining riparian habitat.

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APPENDIX

Common name	Scientific name
Great Blue Heron	*Ardea herodias*
Green Heron	*Butorides striatus*
Great Egret	*Casmerodius albus*
Turkey Vulture	*Cathartes aura*
Sharp-shinned Hawk	*Accipiter striatus*
Cooper Hawk	*Accipiter cooperii*
Red-tailed Hawk	*Buteo jamaicensis*
Swainson Hawk	*Buteo swainsoni*
Zone-tailed Hawk	*Buteo albonotatus*
Harris Hawk	*Parabuteo unicinctus*
Black Hawk	*Buteogallus anthracinus*
Bald Eagle	*Haliaeetus leucocephalus*
Osprey	*Pandion haliaetus*
Prairie Falcon	*Falco mexicanus*
American Kestrel	*Falco sparverius*
Gambel Quail	*Lophortyx gambelii*
Spotted Sandpiper	*Actitis macularia*
White-winged Dove	*Zenaida asiatica*
Mourning Dove	*Zenaida macroura*
Inca Dove	*Scardafella inca*
Yellow-billed Cuckoo	*Coccyzus americanus*
Roadrunner	*Geococcyx californianus*
Barn Owl	*Tyto alba*

Appendix (cont.)

Common name	Scientific name
Screech Owl	Otus asio
Great Horned Owl	Bubo virginianus
Lesser Nighthawk	Chordeiles acutipennis
Black-chinned Hummingbird	Archilochus alexandri
Costa Hummingbird	Calypte costae
Anna Hummingbird	Calypte anna
Belted Kingfisher	Megaceryle alcyon
Common Flicker	Colaptes auratus
Gila Woodpecker	Melanerpes uropygialis
Yellow-bellied Sapsucker	Sphyrapicus varius
Ladder-backed Woodpecker	Picoides scalaris
Western Kingbird	Tyrannus verticalis
Cassin Kingbird	Tyrannus vociferans
Wied Crested Flycatcher	Myiarchus tyrannulus
Ash-throated Flycatcher	Myiarchus cinerascens
Black Phoebe	Sayornis nigricans
Say Phoebe	Sayornis saya
Willow Flycatcher	Empidonax traillii
Hammond Flycatcher	Empidonax hammondii
Gray Flycatcher	Empidonax wrightii
Western Flycatcher	Empidonax difficilis
Western Wood Pewee	Contopus sordidulus
Vermilion Flycatcher	Pryocephalus rubinus

Appendix (cont.)

Common name	Scientific name
Rough-winged Swallow	Stelgidopteryx ruficollis
Cliff Swallow	Petrochelidon pyrrhonota
Common Raven	Corvus corax
Bridled Titmouse	Parus wollweberi
Verdin	Auriparus flaviceps
White-breasted Nuthatch	Sitta carolinensis
Brown Creeper	Certhia familiaris
House Wren	Troglodytes aedon
Bewick Wren	Thryomanes bewickii
Cactus Wren	Campylorhynchus brunneicapillus
Long-billed Marsh Wren	Cistothorus palustris
Cañon Wren	Catherpes mexicanus
Rock Wren	Salpinctes obsoletus
Mockingbird	Mimus polyglottos
Curve-billed Thrasher	Toxostoma curvirostre
Crissal Thrasher	Toxostoma dorsale
American Robin	Turdus migratorius
Hermit Thrush	Catharus guttatus
Western Bluebird	Sialia mexicana
Mountain Bluebird	Sialia currucoides
Blue-gray Gnatcatcher	Polioptila caerulea
Black-tailed Gnatcatcher	Polioptila melanura
Golden-crowned Kinglet	Regulus satrapa

Appendix (cont.)

Common name	Scientific name
Ruby-crowned Kinglet	Regulus calendula
Cedar Waxwing	Bombycilla cedrorum
Phainopepla	Phainopepla nitens
Loggerhead Shrike	Lanius ludovicianus
Starling	Sturnus vulgaris
Hutton Vireo	Vireo huttoni
Bell Vireo	Vireo bellii
Solitary Vireo	Vireo solitarius
Warbling Vireo	Vireo gilvus
Orange-crowned Warbler	Vermivora celata
Nashville Warbler	Vermivora ruficapilla
Virginia Warbler	Vermivora virginiae
Lucy Warbler	Vermivora luciae
Yellow Warbler	Dendroica petechia
Yellow-rumped Warbler	Dendroica coronata
Black-throated Gray Warbler	Dendroica nigrescens
Townsend Warbler	Dendroica townsendi
Northern Waterthrush	Seiuris noveboracensis
MacGillivray Warbler	Oporonis tolmiei
Common Yellowthroat	Geothlypis trichas
Yellow-breasted Chat	Icteria virens
Wilson Warbler	Wilsonia pusilla
Western Meadowlark	Sturnella neglecta

Appendix (cont.)

Common name	Scientific name
Hooded Oriole	*Icterus cucullatus*
Northern Oriole	*Icterus galbula*
Great-tailed Grackle	*Quiscalus mexicanus*
Brown-headed Cowbird	*Molothrus ater*
Bronzed Cowbird	*Molothrus aeneus*
Western Tanager	*Piranga ludoviciana*
Summer Tanager	*Piranga rubra*
Cardinal	*Cardinalis cardinalis*
Black-headed Grosbeak	*Pheucticus melanocephalus*
Blue Grosbeak	*Guiraca caerulea*
Lazuli Bunting	*Passerina amoena*
House Finch	*Carpodacus mexicanus*
Lesser Goldfinch	*Carduelis psaltria*
Lawrence Goldfinch	*Carduelis lawrencei*
Green-tailed Towhee	*Pipilo chlorurus*
Rufous-sided Towhee	*Pipilo erythrophthalmus*
Brown Towhee	*Pipilo fuscus*
Abert Towhee	*Pipilo aberti*
Vesper Sparrow	*Pooecetes gramineus*
Lark Sparrow	*Chondestes grammacus*
Black-throated Sparrow	*Amphispiza bilineata*
Sage Sparrow	*Amphispiza belli*
Dark-eyed Junco	*Junco hyemalis*

Appendix (cont.)

Common name	Scientific name
Gray-headed Junco	*Junco caniceps*
Chipping Sparrow	*Spizella passerina*
Brewer Sparrow	*Spizella breweri*
White-crowned Sparrow	*Zonotrichia leucophrys*
Lincoln Sparrow	*Melospiza lincolnii*
Song Sparrow	*Melospiza melodia*

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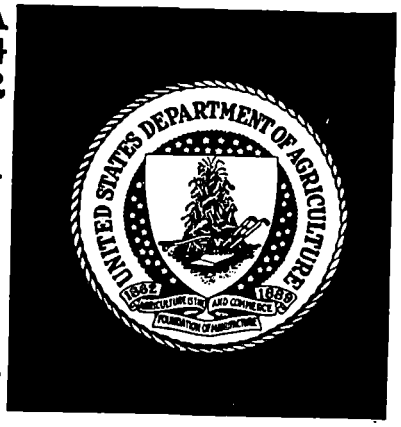

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